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WILLIAM HUGGINS, ESQ., F.R.S., President, in the Chair.

Sun-Spot Drawings of the Rev. Frederick Howlett and Hofrath Schwabe.

The Rev. Frederick Howlett has presented to the Society five oblong quarto volumes of Sun-spot Drawings, made by him in the course of the last seventeen years. In the first four volumes the whole of the Sun's disk is given on a scale of about three and a quarter inches to the Sun's diameter; the places of the spots, and the outlines of the groups and penumbræ, were laid down while the image of the Sun was thrown upon the paper by means of a three-inch refracting telescope by Dollond. Enlarged drawings of the more remarkable spots are also given. In the later volumes the drawings are made upon tracing paper, which is reversed in the book, so that they appear as if seen with an ordinary erecting eye-piece. The position of the north point is not marked upon the drawings, but as the hour and minute corresponding to the time of observation is in all cases given, the orientation of the Sun's disk may be approximately determined by calculation, the highest part of the drawing on the page being assumed to coincide, in the case of the earlier sketches with the part of the Sun's disk nearest to the horizon, and in the case of the later drawings with the part of the solar disk highest above the horizon.

In compiling the list of Sun-spot manuscripts, given in the March number of the *Monthly Notices*, the manuscript Observations of Hofrath Schwabe were by accident omitted. In 1864 Messrs. De La Rue and Balfour Stewart wrote to Hofrath Schwabe to request that he would allow his original manuscripts to be sent to England. In answer to their letter, the following communication was received:

"Gentlemen,—The request contained in your letter, although in the highest degree honourable and complimentary to me, and although it gives me an opportunity to show the Royal Astronomical Society my gratitude for the Royal Medal granted to me, has still cost me some struggle before complying with it, for it is not easy to part with what has given me very often much pleasure and enjoyment as a compensation for the labour devoted to the work.

"But in complying with your desire I do so on one condition, viz. that you would grant me permission to obtain the Observations back again at any time that I should be desirous of looking into them during the short time of life still left to me. I do not think that I shall have an occasion to avail myself of the permission asked for; but permit me kindly to believe that it is in my power to do so. After my death you may consider the whole of the Observations as the property of the Royal Astronomical Society.

"Please to write me if you are willing to agree to the above desire, and I shall then immediately send you my astronomical diaries, &c., from 1825 to the end of 1864.

"I remain, gentlemen, yours very faithfully,

"S. H. Schwabe."

On receipt of this letter Mr. Loewy was despatched to Dessau by the Directors of the Kew Observatory, and Hofrath Schwabe delivered into his hands thirty-nine volumes, which have remained at Kew until the present time, but which are held by the Observatory as the property of the Royal Astronomical Society.

The following description of the manuscripts has been given by Mr. Whipple:—

1825. Small quarto; about 60 pages; commencing Sept. 30; principally occupied with detailed observations and drawings of the Lunar Surface. The first Sun-spot observation occurs on Oct. 30. Occasional details and positions given to end of year. Stitched; paper cover.

1826. Small quarto; about 400 pages. Contents similar to preceding vol. Some of the drawings very elaborate. In addition, there are several observations of *Saturn*, and a Table of Contents. Stitched; paper cover.

1827. Small quarto; about 400 pages. Contents similar to preceding vols. Has several drawings of *Jupiter* and one of *Venus*. Table of Contents. Half-bound; leather back.

1828-29. Large quarto; about 400 pages. Drawings and details of Sun-spots very numerous. A few drawings of other objects. Bound in brown holland.

1830. Large quarto; about 200 pages. Contents similar to preceding. Contains a series of well-executed drawings of *Mars*. Brown holland binding.

1831. Small quarto; about 300 pages. Sun-spot drawings, principally confined to indications of position. A number of drawings of *Jupiter*; scarcely any of lunar objects. Half-bound; leather back.

1832. Large quarto; about 200 pages. Very similar to last. Bound in brown holland.

1833-4-5. Three large quarto vols., each containing about 200 pages. Contents chiefly Sun-spot positions. Vol. for 1835 contains numerous drawings of Halley's Comet. Brown holland binding.

1836-7-8. Large quarto; about 350 pages. Contains drawings of Sun-spot positions, one observation of *Mars*, and a series of drawings of Encke's Comet. Brown holland binding.

1839-40. One vol.; foolscap; about 300 pages. Principally Sun-spot positions. Holland binding.

1841-51. Eleven vols.; large quarto; each averaging 250 pages. Contents similar to preceding. Drawings of other objects than Sun-spots are very few. Vol. for 1843 contains summary of Sun-spot groups observed from 1825 to the end of 1843. Holland binding.

Note.—A remarkably fine Sun-spot is delineated for Sept. 20, 1848. From 1846, at end of each year, there is a detailed summary of the Sun-spot observations made during the year.

1852-62. Eleven vols.; large quarto; each averaging 200 pages. Similar in character to preceding volumes. That for 1855, on the 25th of Sept., contains a nicely-finished drawing of *Jupiter* in colours. Brown holland binding.

1863-4-5. Three vols.; large quarto; about 100 pages each; containing observations of the usual character. Bound in brown holland.

1866-67. Unbound; stitched paper; about 100 pages each. They do not possess the Annual Summary of Sun Observations, which was discontinued in 1865.

On Lohrmann's and Schmidt's Lunar Maps, and Note on a New Red Star. By John Birmingham, Esq.

(*From a Letter to E. Dunkin, Esq., Secretary.*)

Perhaps you would be kind enough to inform the Society at the next meeting that Lohrmann's complete Map, of which four sections have been hitherto published, has been lately engraved by Herr J. A. Barth, of Leipzig, under the supervision of Dr. Schmidt, Director of the Athens Observatory, who has contributed a descriptive letter-press. The map is three feet in diameter.

Dr. Schmidt's own great Lunar Map of six French feet diameter will be soon issued from the *atelier* of the Prussian staff; the Prussian Government having, with great credit to itself, purchased it. It is the result of thirty-four years' labour, containing about 34,000 craters, and an equal number of hills, besides over 350 rills and other objects, and it must be considered a work of unsurpassed scientific capability and perseverance.

I beg you will also inform the Society that I have lately observed a red star of remarkable depth of colour in the approximate position of R.A. = $18^h\ 28^m$; Decl. = $+\ 36°\ 54'$; 8·3 magnitude. It does not appear as a red star in any Catalogue that I know of.

Millbrook, Tuam,
1876, *May* 10.

On recent American Determinations of Geographical Positions in the West Indies and Central America.

By Major H. S. Palmer, R.E.

A few nights ago, I paid a visit to the temporary Observatory of Lieutenant-Commander F. M. Green, of the United States Navy, erected at Rickett's Battery in this place (Barbados, West Indies). The astronomical work in which Commander Green is engaged under the American Hydrographic Office is of so highly useful and practical a character that I think a short notice of it is likely to interest the Society, or at least those of its Fellows who are practical field astronomers. It is the determination, with an accuracy much greater than any yet attained, of the geographical positions of various points in the West Indies and Central America, which are connected with one another by telegraphic cable. The latitudes in these operations are found by the method very generally used by American astronomers, of observing pairs of stars on the meridian, N. and S., with the zenith-telescope; and the longitudes, by means of telegraphic comparisons of local times. The work was begun in the winter of 1874-5, at the suggestion, I believe, of Commander Green; the U.S.S. *Fortune* was commissioned for the purpose, and Commander Green, with a sufficient staff, was placed in charge of her. During the first season, the latitudes and relative longitudes of Panama, Aspinwall, Kingston, Havana, and Santiago de Cuba were ascertained with great precision. It was intended to connect Havana at once with a station of the U.S. Coast Survey at Key West, but this was prevented by an outbreak of yellow fever. The connection has, however, been made in the winter just ended, and the work generally of this second season has been prosecuted with vigour by Commander Green and his officers, in a fresh ship, the *Gettysburg*, the *Fortune* having proved unfit for the service. Besides connecting Havana with Key West, they have determined latitudes and meridian distances at St. Thomas, Antigua, Trinidad, and Barbados, and are now at work at Martinique, where the season's operations end. In the second series of measurements, the intention at first was to establish a fixed station at St. Thomas, and measure back to it from the other islands; but this plan could not be adhered to, owing to the condition of the cables. St. Thomas having first been connected with Kingston (determined in the previous season), distances were first measured from St. Thomas to Antigua and Trinidad, then from Trinidad to Barbados and Martinique.

It is confidently anticipated that the results of the two seasons' work will prove such as to justify an extension of the measurements next year to the mainland of South America, and along both coasts, so as to settle indisputably the much-vexed question of longitudes on that continent. So far as the work has yet gone, its usefulness has been proved by the detection of considerable errors in previously received positions. It has also proved highly

accurate and comparatively inexpensive. It is indeed plain that, when once the outfit, by no means a costly one, has been supplied and the staff trained, there the special expense of work of this kind practically ends. Any cruiser or surveying ship can carry on the measurements without prejudice to its routine services; and experience thus far has shown in the most gratifying manner that both foreign authorities and officials of telegraph companies are always ready to extend courtesy and gratuitous help to scientific work of the kind.

I proceed now to sketch the *modus operandi*, illustrating it by taking two stations, say Barbados and Trinidad, at both of which places observatory sites have been chosen by Commander Green, he himself on this occasion operating at Barbados, while his assistant, Professor Rock, is at Trinidad. The huts and instrumental outfits at both stations are exactly alike, with one exception only—the huts are of different colours. The instrumental outfit at each consists of a transit instrument adapted for use also as a zenith-telescope, a break-circuit sidereal chronometer, a small chronograph driven by a weight, keys for speaking and signalling, a Thomson's "mirror galvanometer," batteries, telegraphic fittings, lamps, &c. The transit pier is of brick, faced with cement, and is square in shape, its top surface consisting of four tiles, each about a foot square, laid and levelled with extreme care. The meridian line is laid out with a compass in the usual way. The instrument is of the large portable kind, and has a universal movement, with a horizontal circle of about ten inches diameter, a form of construction which admits of its being very readily used, if required, for observations in the prime vertical. Its base consists of a tripod-stand, with footscrews, carrying a cylinder which receives the vertical axis, and to which the horizontal circle is fixed. From the head of this axis, two opposite arms extend horizontally, and are then bent up to form the supports for the telescope axis, which are about eighteen inches apart. The telescope is of the axis-view construction, and its object-glass is of about $2\frac{3}{4}$ inches clear aperture, and 27 inches focal length. The finding-circle is on the eye-end of the axis. The transit threads are eleven in number, viz.: a central group of five, with a group of three a little on either side of it, all of them being fixed. There are the usual central horizontal threads, and others arranged obliquely for zenith-telescope work; there is also a movable zenith distance micrometer wire.

This instrument, like most of its class, is subject to one rather serious source of error, through flexure of its transverse axis, the error produced varying, just as a level error, with the cosine of the zenith distance of the body observed. The extent of this defect was however carefully investigated in the United States before the expedition set out, and a coefficient of flexure was found for each instrument, from scrupulously careful observations at every 5° of zenith distance.

The hut, about 9 feet square, has its door in the middle of the

north side. On a table in the north-east corner is the break-circuit chronometer, in connection with a small barrel chronograph driven by a weight and wheel-work, which stands on a little table in the north-west corner. The performance of this chronograph is very satisfactory. A pencil attached to the electro-magnet describes an endless spiral on the chronograph sheet, making however a little nick or notch whenever it is momentarily moved aside by the action of the electro-magnet, either through the operation of the chronometer at each second or from the observer's tap with his break-circuit key. The numeration of seconds is marked in the usual way, by omitting the record of one second in each minute. On the same table with the chronometer is the speaking instrument,* connected with the head telegraph office, and used also in the time-signalling; and above it is the Thomson's galvanometer, its mirror reflecting a small rectangular patch of light from an orifice in a screened lamp on to a sheet of white paper fastened to the wall of the hut above the table. The break-circuit key used in tapping transits, &c., for chronographic register, with its attached wires, is movable. During transit observations, it can be held in the hand, or laid on the pier: Commander Green preferred the former.

I was with Commander Green on his first night's work at this place. There was nothing new in his method of adjusting the instrument to the meridian. It was done, however, with most unusual speed, partly owing, no doubt, to an admirable printed form of "Programme," in which the observer enters beforehand the name, position, magnitude, setting, &c. of every star he intends to use, and is thus able to proceed from star to star with the least possible loss of time. Twelve minutes' work enabled Commander Green to get his instrument very approximately into position.

For the time determination, clock stars of north declination, and therefore near the zenith, of this place, were chiefly used. The level (a most excellent one) was on this account read very frequently; but, as the construction of the instrument allows of the level being kept on the pivots without being disturbed except for reversal, this gave little trouble. Some clock stars a little N. of the zenith, and some S. of it, were observed. The usual routine is to observe 3 or 4 circumpolar, and 8 or 10 clock stars nightly, about half of each before and after time-signals, and half in each position of the axis, reversal being made on a circumpolar star once in the evening. A test value of the collimation error of the middle wire is obtained from this reversal; but in the reduction, both the collimation and azimuth errors are treated as unknown in the series of equations for clock error, and are rigorously solved for by the method of least squares.

In time-signalling, the process is as follows:—Let B and T be the operators at Barbados and Trinidad respectively. About

* This is a double "Key" for sending positive and negative signals.

sunset, weather prospects are telegraphed between the two, and these being satisfactory, arrangements are made for signalling at about 9^h or 10^h. At the appointed time, B calls T, and finding him ready, seats himself at the chronometer, and sends the following signals:—

A warning rattle, beginning at 50 secs., and lasting for 5 secs.

Single signals, at 0^s 5^s 10^s 15^s 20^s . . . . and so on to 60 secs.

A rattle at 5 secs., lasting for 5 secs.

T, having darkened his hut sufficiently, just acknowledges the warning rattle: then, taking the movable break-circuit key, which is in circuit with the chronograph, into his hand, he watches for the first movement of the patch of light which is reflected on the white paper from the Thomson's galvanometer. Each five-seconds signal sent by B is recorded on the chronograph when received by T, who strikes his key every time directly the light-spot is seen to move. The single signals over, T acknowledges B's last rattle.

B now promptly telegraphs the hour and minute of his first single signal, and T acknowledges it.

At the next 50 secs., B begins again with a rattle, and exactly repeats with T the above operation; and this is done five times in all.

Then T takes the sender's, and B the receiver's place, in precisely the same manner, for five minutes. This ends the night's signalling.

Three such nights of comparisons are considered to be sufficient for a pair of stations.

The time occupied by the passage of signals from the sending-point through the cable (up to the instant of visible movement of the light-spot), and also through the chronograph circuit at the receiving station, may be considered as eliminated by sending the signals both ways. But, as the observers do not change places at any pair of stations, there will remain as constant sources of error, affecting measurements of meridian distances by this method, the personal equations of the observers, (1) in observing transits; (2) in tapping the key at the sending station in coincidence with the chronometer beats; (3) in tapping the key at the receiving station simultaneously with the first visible movement of the beam of light. These sources of error have been carefully gone into amongst the observers engaged in the work.

For determining the absolute personal equations in observing transits, a "personal-equation machine" was used. Two or three kinds of this apparatus have, I believe, been brought out in the United States. An account of one, devised by himself, is given by Professor W. Harkness, in the Appendix to the *Washington Observations*, 1870. The principle of it is, that a series of five artificial stars attached to a chronograph cylinder is made to transit a single wire in a fixed telescope, at an apparent angular velocity corresponding with that of an equatoreal star crossing the wires of the transit instrument in the meridian, and at cor-

responding intervals of time. The observer records chronographically the transit of each star over the wire, and the difference between his record of any transit and the previously-made mark on the chronograph sheet which corresponds with actual bisection of the star gives a measure of his absolute personal equation. Another kind of the same instrument was mentioned by Commander Green. I have not seen a written account of it, but I gather from his description that, in this case, a system of wires is made to move past a single star, instead of a set of stars past a single wire. As each wire passes, not exactly the star, but a point at a certain small known interval from it, it makes an automatic register on the chronograph. The observer also registers the transit on the same chronograph; and a comparison between the two registers, making due allowance for the small interval abovenamed (which is contrived purposely that there may be no confusion), gives a measure of the personal equation. The size of the artificial star can be varied to represent stars of different magnitudes.

The two kinds of personal equations in time signalling are found in combination, I believe thus: Two break-circuit chronometers, C_1 and C_2, are both made to register their beats on the same chronograph cylinder, for some little time, so as to give an absolute comparison between them, and the rate of gain of one upon the other. The observers now proceed to compare C_1 and C_2 in a similar manner to that described for time signalling. B goes to C_1 and sends signals by ear, which T receives by the Thomson's galvanometer and registers on the chronograph, which remains connected with C_2. The difference between the comparison of C_1 and C_2 thus obtained, and their absolute comparison (allowing for rate), may evidently be taken as the sum of B's personal equation in sending, and T's in receiving. B and T now change places, and repeat the above operations, in order to find the sum of T's personal equation in sending and B's in receiving. This is all that is needed, as the double operation gives the corrections to be applied in the case of either observer sending while the other receives.

In determinations of latitude with the transit instrument used as a zenith-telescope, from 6 to 12 pairs of stars observed on the meridian on three nights, making from 18 to 36 determinations in all, are considered to give a result sufficiently good, probably within about $0''{\cdot}5$ of the truth.

From the account I have here given of Commander Green's operations in these seas, it will, I think, be seen that they are simple and thoroughly practical, and executed with an accuracy which leaves nothing to be desired, being in fact surrounded with all the precautions and safeguards which should be looked for in work of a precise order. I believe that this is the first naval expedition as yet made for establishing secondary meridians by telegraphic time comparisons, and for exact determinations of latitude. The region which has been chosen is in every respect

well suited for a first experiment, the facilities being great and the field large, while many uncertainties in the longitudes, especially on the south shore of the Caribbean Sea, where they amount to some five or six miles, need to be cleared up. In other parts of the world, however, the uncertainties are a good deal greater. It is not too much to hope that other nations will promptly follow the lead taken by the American hydrographers, and that especially our own Hydrographic Department will add this branch of work to the admirable maritime surveys in which it is justly pre-eminent. The vast and constantly spreading network of telegraphic cables and land lines will afford work for many years to come; and each extension of measurements of the class I have described will add accuracy to geographical knowledge and marine cartography.

Barbados, West Indies,
1876, *March* 20.

On the Relative Power of Achromatic and Reflecting Telescopes.

By T. R. Robinson, D.D., F.R.S., &c.

In an article which appeared in *Les Mondes*, Jan. 20, 1876, by M. Radau, on large Telescopes, he remarks, after noticing the comparison of the relative illuminating power of Achromatics and Reflectors, which I made in the description of the Great Melbourne Telescope (*Phil. Trans.* 1869), "the theoretic proportion established by Mr. Robinson between equivalent apertures of a Reflector and Refractor is not however conformable to experience, which is entirely in favour of the Refractor."

Even were it true that an Achromatic shows objects better than an equivalent Reflector, it would not contradict my theory, which merely refers to light. The theory is, in brief, that a speculum collects in its focus a quantity of light proportional to its area, and a constant depending on the reflective power of its material; the Achromatic a quantity depending on its area, and a co-efficient which contains a negative exponential function of the aperture, and of course decreases more rapidly than the area increases. Therefore, though for small apertures the light of the Achromatic exceeds that of an equal speculum, yet as the aperture increases, the disparity decreases until at a size determined by the reflective power of the speculum and the refractive indices and absorptive power of the glasses, their lights become equal; and above that the Reflector predominates. Since, therefore, both the difficulty and cost of construction increase far more rapidly with aperture in the Achromatic than in the Reflector, it is evident that as far as light is concerned, the ultimate practical limit of telescopic research can only be obtained by the latter.

Having premised so much, I proceed to consider (1) what

reasons can exist for the superiority that is ascribed to the Achromatic, and (2) whether they *do* exist.

If one of two equiluminous telescopes shows a faint object better than the other, this can only arise from the first condensing its light into a smaller image. In this respect the Achromatic presents greater difficulties than its rival: it has two aberrations to be corrected, chromatic and spherical, of which the first is never completely destroyed,* and the second requires the careful figuring and centering of four surfaces; any defect of homogeneity in its glasses disturbs the image; defective annealing, from which scarcely any large lenses are free, tends to produce diffusion, and the same mischief may arise from strain caused by pressure on its supports.

On the other hand, a speculum has only one surface to be figured, and with the present improved processes of polishing, *that can be done with remarkable precision.* But it is very sensitive to irregular pressure. This has been greatly remedied by the systems of supporting levers invented by Grubb and Lassell, which may probably be still further improved; and I believe that by a better mechanical disposition of the material, its strength may be greatly increased. The only point in which it is decidedly inferior to the object-glass is the occurrence of convection currents when the speculum and the air differ much in temperature. Even this is greatly obviated by making the tube of lattice-work, and it would not be difficult to devise mechanical means to reduce it still further. It is also to be noticed that there are some grounds for believing that large Achromatics have their aberration correction disturbed by considerable changes of temperature.

On the whole, therefore, it may be expected that a good instrument of either class shall perform equally if equal in light; and it is certain that superior definition will compensate only to a very limited extent for deficiency of light.

But secondly, what evidence have we that "Experience is entirely in favour of the Refractor?" None that will bear examination.

1. We are told that W. Struve thought the Dorpat telescope of 9·6-inches aperture might be compared to Herschel's 20-feet of 18-inches aperture. This rested mainly on the fact, that he discovered with it the 5th star in the Trapezium of *Orion*, which was not seen by J. Herschel in his careful examination of the Great Nebula. The obvious explanation of this is, that Herschel was attending to the Nebula and nothing else. But, in fact, his telescope showed not only the 5th, but also the 6th star which was in the Dorpat. Lassell saw both in a 9-inch Newtonian; and I have myself seen the 5th with a zone of the Armagh Cassegrain,

* It is doubtful whether the Harcourt glass, with which Mr. Stokes has recently formed an object-glass free from secondary spectrum, can be made on a large scale.

the area of which was only 0·78 that of the Dorpat. This object is, therefore, far within the range of any of these telescopes.

2. Otto Struve *thought* that the Pulkowa Achromatic of 15-inches was equal to Lassell's 24-inch Newtonian (not his 4-feet, as supposed by M. Radau): nothing definite can be built on this. It seems only to have shown three satellites of *Uranus*, while the other (Lassell's) showed four.

3. We are told that M. D'Arrest's Achromatic of 11-inches aperture "is very superior to Herschel's 20-feet, and almost equal to the great telescope of Lord Rosse."

D'Arrest himself, though very enthusiastic about his instrument, makes no such pretensions. In his *Instrumentum Magnum* he merely says, that "he could reach with his telescope all the Herschel Nebulæ without any exception," and in the preface to his great Catalogue that "it is in no wise inferior, non ullo nomine postponendum, to the Herschel telescopes on which this part of science had been built." But seeing all these Nebulæ does not prove that the telescope was equal in power, unless all the other conditions were identical. (1.) It is far easier to see an object the existence, place, and form of which are known than to discover one that is unknown; examples of this are familiar to every one who has used a telescope. (2.) He had the great advantage of a steady Equatoreal moved by clockwork; this gives a power of minute examination, the value of which can be appreciated only by persons who have worked with telescopes mounted like those of Herschel and Rosse. (3.) Much depends on the observer's power of vision; if M. D'Arrest were as sharpsighted as, for instance, my friend the late Mr. Dawes, this would compensate for considerable deficiency of optical power. No satisfactory comparison can be made from the descriptions in catalogues; they are always incomplete. No description of a tolerably complex nebula would enable a man who had not seen it to make a drawing at all like it. D'Arrest, in his *Instrumentum Magnum* has given some figures, which show superiority to those of Herschel where they differ; and where they are also given in Lord Rosse's papers (*Phil. Trans.* 1844, 1850, 1864), Herschel is on the whole nearer to these last than D'Arrest. As to the notion that the Danish telescope "is almost equal to Lord Rosse's great one," we have only to compare D'Arrest's fig. 4, of 1 M, with Rosse's fig. 81, *Phil. Trans.* 1844, taken with the *three-feet*, to be convinced that even this lesser telescope is enormously superior to the other.

Let it also be remembered that while two of the satellites of *Uranus* were *observed* repeatedly with the 20-feet, there is no evidence that any of them were ever *seen* in an 11-inch Achromatic.

All these statements of the superior power of Achromatics are so little supported by accurate data, that it may seem a waste of time to confute them, but such baseless assertions "darken knowledge" and if accepted, impede progress. I repeat my belief that it is only by large Reflectors that we shall reach the utmost depths

of celestial exploration in stellar spectroscopy, and the study of the remoter planets and Nebulæ; and, instead of unwisely depreciating this power, it is a wiser course to consider how their real defects may be remedied.

Of these the most serious is the liability of speculæ to tarnish, and the consequent necessity and risk of frequent repolishing. Has science no means of preventing the tarnish, which is an oxidation of the surface probably caused by the presence of moisture?

Lord Rosse and I separately tried to guard against this by connecting with the speculum box (when the instrument was not in use) a vessel containing quicklime; but I have some reason to think that as it became "slacked" it evolved something that acted on the metal.

Would it be protected by keeping it in a state of negative electric tension? Sir John Herschel told me that when his father sorrowfully showed him a 20-feet speculum, the finest he had ever made, but then become black, he delighted the old man by restoring completely its polish, having placed it in a solution of salt in contact with a piece of zinc; and afterwards it did good work.

The operation of polishing even a 6-feet, is neither so difficult or uncertain as many persons suppose. If, when the right mode of making the polisher, and the proper action of the machine, are once ascertained, they be exactly formulated, *and that formula be always carefully followed*, I venture to assert that failure will be very rare.

The late Lord Rosse—while, with that caution which was so remarkable a feature of his character (*Phil. Trans.* 1864), he rather overstates the uncertainty in the process—also says, that in every such instance something which experience had shown to be important had been forgotten or neglected. In the case of the 6-feet, the difficulty was much increased by the impossibility of testing the figure of the speculum while the polishing was proceeding: it had to be removed to the telescope half a mile distant for trial, which owing to unfavourable weather sometimes could not be made for many days; and this suspension was unfavourable, for the operation should be continuous. This, and the trouble of moving so great a mass, sometimes made him work with surfaces of second-rate quality. Towards the close of his life he contrived the means of setting the speculum vertical on the machine, so that in a few minutes it could be tested on a watch-dial. The 3-feet was from the beginning tested on the machine, and success with it was almost certain. But even with the old method I have seen results for the 6-feet that gave marvellous definition, and none that in favourable atmospheric circumstances were not capable of doing work beyond the power of any telescope which then existed. The time of actually polishing it need not exceed 6 hours; and though he never used the same polisher twice (the making of which is rather tedious) yet neither Lassell or Grubb have found this necessary for 4-feet specula. It is to be wished

that some ready means may be found for trying the diminution of light by tarnish. I think, if the image of a lucid disk were formed beside it at the centre of curvature, the two could be photometrically compared rapidly and without moving the speculum from the tube.

As to the ultimate possible size of a speculum of metal, an accident that occurred in casting a 6-feet, at which I was present, satisfied us that one of 7-feet could be made; nor is this the limit. But if the 4-feet "Foucault" just erected at Paris prove, as I hope it will, a great success, it is probably in that direction that the improvement of very large specula will tend. It will probably be difficult to form large glass disks with sufficient uniformity of strength in every direction, to resist distortion; but on the other hand, silver is so much more reflective than speculum metal,* that its equiluminous aperture will be only $\frac{2}{3}$rds of the other.

I look to this telescope with great interest; for, from it in conjunction with the great Refractor which is now in construction for the Observatoire, can alone be expected a really accurate comparison of the Achromatic and Reflector. As I have elsewhere stated, such comparison can only be fairly made when the conditions are identical; when the locality, the night, the object, the observer are the same; and I may add, when there is no personal or party bias in the judge. An observer becomes in some cases so much attached to his instrument as almost to identify himself with its character; and it may even happen that national feeling is interested in favour of a particular artist. All will be favourable at the Observatoire, and I trust that M. Le Verrier and his accomplished assistants will profit by so auspicious an opportunity.

On the Transit across the Sun's Disk of the Second or Great Comet of 1819. By J. R. Hind, Esq.

The second or great Comet of 1819 made its appearance in these latitudes under circumstances very similar to those attending the early visibility of the great Comet of 1861. It ascended above the north-west horizon as a conspicuous naked-eye object, and was very generally detected in Europe in the first days of July. The earliest observation for position appears to have been made by Professor Tralles at Berlin on the evening of the 1st of the month, and the latest observations were made by Struve at Dorpat and by Olbers at Bremen in the middle of October.

* The mean of Jamin's co-efficients for silver at perpendicular incidence is 0·90, which gives for the Newtonian 0·81, greater than that of most Achromatics. It is, however, doubted whether a film reflects as much as solid silver. A Committee has been appointed by the British Association to examine this, and some other cases of reflection.

The comet passed its perihelion on the morning of June 28, and consequently was already receding from the Sun, when it first attracted attention in Europe.

Olbers calculated parabolic elements from observations between July 2 and 9, which he communicated to Bode in a letter dated July 27; and it was in this letter that he announced his discovery from his own orbit of the notable fact, that a transit of the comet across the Sun's disk must have taken place at the passage of the ascending node early on the morning of June 26, or two days before arrival at perihelion, and therefore while astronomers were ignorant of its presence. His first calculation gave for the time of ingress June 25, $17^h\ 39^m$ Berlin mean time, and for that of egress $21^h\ 18^m$: at $19^h\ 30^m$ the comet according to this computation would have been only $1'\ 27''$ west of the Sun's centre. Olbers also remarked on the interest that would attach to any examination of the spots upon the Sun's disk, that might have happened to be made during the time of the transit.

General von Lindener of Glatz, in consequence of this notice from Olbers, reported to Bode that he had looked at the Sun at 5^h, 6^h, and 7^h, on the morning of June 26, and found it without any spots. He states that he had been in the habit of examining the Sun's disk since the year 1800, and that in 1819, although in his seventy-seventh year, he observed it two or three times daily with an achromatic by Ramsden of $2\frac{1}{2}$-feet, and powers 25 and 75.

This statement of the invisibility of spots on the morning in question was contradicted by the evidence of Professor Schumacher, who at 8 A.M. at Altona, had viewed the Sun's disk, as on several preceding mornings, though only with the telescope of a 7-inch Troughton sextant, but on no occasion had found it free from spots. Professor Brandes, of Breslau, had remarked one spot shortly before noon, "in its proper place near exit." Gruithuisen, at Munich, at 8 A.M. found two spots near the western limb and one in the middle of the disk, and he gave his reasons for supposing that the latter was either "a new opening" or the nucleus of the comet. Wildt, of Hanover, has also put upon record that *about June* 26, at 7 A.M., "at most one or two days earlier or later," he saw an ill-defined confused spot, which he considered to have been the comet.

But the most definite observations, and those which I propose more particularly to examine here, are that of Privy Councillor Pastorff, of Buchholtz, near Frankfort-on-the-Oder, whose Sun-spot drawings and manuscripts were some years since presented, by Sir John Herschel, into whose possession they had come, to the Library of the Royal Astronomical Society; and the observation of Canon Stark of Augsburg.

Pastorff communicated the details of his observations to the Baron de Zach in a letter dated 1824, November 25, which is published in the *Correspondance Astronomique* &c. t. xi. p. 550.

He writes:—"Permit me to communicate to you yet another very curious observation which I found by accident in filing my old papers: it is not an observation made à la D'Angos; it is quite certain and made with the greatest precision. On the 26th of June, 1819, on looking at the Sun, I saw very distinctly upon its disk a nebulous spot and three black ones. The nebulous spot was perfectly round and slightly luminous. I am persuaded it was the comet, which, according to the calculations of M. Olbers, ought to pass over the Sun's disk June 26, 1819, at $5^h\ 47^m$ A.M. The roundness, the nebulosity, the luminous point in the centre appeared to me so remarkable, that I made a sketch as correctly as possible. At $8^h\ 26^m$ A.M. this nebulous spot was $84''{\cdot}5$ in diameter, and its distance from the south-east limb of the Sun was $6'\ 10''$. On the 27th of June, on looking at the Sun about 9 A.M., the nebulous spot, as well as one of the black spots, had disappeared. The other two black spots which on June 26 at $8^h\ 26^m$ A.M. were distant $36''$ and $34''$ respectively from the limb of the Sun, were already at a distance of $6'$ therefrom." Pastorff gives, for the position of Buchholtz: longitude $0^h\ 49^m\ 45^s{\cdot}5$ E. of Paris; latitude $52°\ 26'\ 50''$.

Canon Stark's observation at Augsburg is found in his *Meteorologisches Jahrbuch* which contains regular observations of solar spots. He states that at $7\frac{1}{4}$ A.M. on June 26, he saw a remarkable spot which "was neither like an opening nor shallow,' and in which there was no black depth (*schwarze Vertiefung*); the spot was small and not well defined. It was $15'\ 25''$ from the west limb and $14'\ 30''$ from the north limb of the Sun; hence not far from the centre of his disk. Stark adds that, at noon, his second hour of observation, the spot was no longer visible.

Some years since I calculated the circumstances of the transit of the comet across the Sun's disk, making use of the Parabolic Orbits of Dirksen and Nicolai, with Carlini's Tables for the Sun. The comet's positions from the two sets of elements were not found very accordant, and though confirming in general Olber's computation,* it appeared worth while to attempt a closer determination of the orbit, and this I have lately made. From observations between 1819, July 3 and October 12, by Gauss, Nicolai, Olbers, and Struve, I obtained the following parabola:—

T	1819, June 27·71547, Greenwich Mean Time.			
	°	′	″	
π	287	8	10·8	} Mean Equinox, 1819, July 0.
Ω	273	41	56·8	
i	80	44	38·1	
log q	9·5332327			

Motion direct.

* Bode's figure in *Berliner Jahrbuch*, 1823, is not drawn correctly.

This orbit is by no means to be regarded as a definite one. Indeed, I found reason to infer that the comet's motion was not closely parabolic, and I will take this opportunity of suggesting that it deserves a thorough investigation. My only object was to secure elements which may be relied upon as giving the comet's geocentric place during the transit within a very few seconds of arc.

From Le Verrier's Solar Tables, I found for June 25 at $19^h\ 15^m$ mean time at Augsburg$=18^h\ 40^m\ 44^s$ Paris mean time:

	°	′	″
Sun's Apparent Right Ascension	94	5	46·9
„ „ Declination	+23	24	42·0
Hourly Motion in R.A.	+	2	35·7
„ „ in Decl.	−	0	4·0

Earth's log Radius-vector $0{\cdot}0071930 + 0{\cdot}0000008.t^h$

And from the above elements

	h m s 16 40 44 Paris M.T.			h m s 20 40 44		
	°	′	″	°	′	″
Comet's True Right Ascension	94	3	9·0	94	13	49·6
„ „ Declination	+23	6	49·1	+23	41	11·6

The aberration in R.A. $= -14''{\cdot}8$; in Decl. $= -47''{\cdot}7$.

The sidereal time at Greenwich mean noon, June 25 $= 6^h\ 11^m\ 9^s{\cdot}0$.

Calculating from these data, as we should for *Mercury* or *Venus*, the following times for ingress or egress of the comet, referred to the centre of the Earth, and expressions for reduction to the surface, are obtained:—

	Greenwich M.T. h m s	
Ingress	16 52 54	$+[1{\cdot}4605].\rho.\sin l - [1{\cdot}1369].\rho.\cos l.\cos.(\lambda - 125\ 45)$
Egress	20 29 56	$+[1{\cdot}4595].\rho.\sin l - [1{\cdot}1412].\rho.\cos l.\cos.(\lambda - 147\ 21)$

The ingress would take place at 172°·2 from the Sun's north point, counted as in double-star measures, and the egress at 8°·7, so that the comet crossed his disk, from south to north, very nearly in the direction of the circle of declination passing through his centre.

For the present purpose, however, the following figures are more available:—

Greenwich Mean Time. h m s	Apparent Right Ascension. (Comet−Sun.) ′ ″	Apparent Declination. (Comet−Sun.) ′ ″
16 31 23	+2 18·7	−18 48·7
18 31 23	+2 27·6	− 1 29·4
20 31 23	+2 36·5	+15 49·8

Assuming for the semi-diameter of the Sun the Greenwich value at the Earth's mean distance, the apparent semi-diameter during the comet's transit would be 15′ 46″·0, hence at the time of Stark's observation the comet's calculated position is 13′ 18″ from the Sun's eastern limb, and 14′ 17″ from his southern limb; which position, compared with the observation, shows a difference of 2′ 49″ in R.A., and 2′ 45″ in Decl. For the time of Pastorff's observation, corresponding to $19^h\ 26^m\ 54^s$ Greenwich mean time, we have from the above numbers—

	′	″
Comet East of Sun's Centre	2	32
Comet North „ „	6	31

which differs widely from the position assigned by Pastorff—6′ 10″ from the Sun's south-eastern limb.

The small effect of parallax is neglected in both cases.

I have been favoured by Mr. Ranyard with a copy of Pastorff's drawing, the original of which, as already stated, is in the Society's archives. The object represented as having been observed upon the Sun's disk is certainly a very remarkable one, bearing every resemblance to the ordinary figure of a telescopic comet, and quite different from the forms of sun-spots. If, however, Pastorff really saw the comet upon the solar disk, his account of its position must be very erroneous.

Stark's position also is open to some doubt, though much nearer to that which the comet must have occupied at the time of his observation; it may perhaps be granted that he possibly saw the comet upon the Sun. Nevertheless, it is impossible not to remark the great difference between his description of its appearance and that given by Pastorff. It appears very improbable that a comet seen in projection upon the Sun's disk would present the cometary aspect which Pastorff describes; it is far more likely that the nucleus only would be discerned. If Pastorff's observation is a *bonâ-fide* one, what he really did see must remain an enigma. I will merely add in conclusion, that there are other observations of his which are exceedingly difficult of comprehension.

Note on the Displacement of Lines in the Spectra of Stars.

By W. H. M. Christie, Esq.

In recent Numbers of the *Comptes Rendus*, P. Secchi has called attention to some apparent discordances between the Greenwich results for the motions of stars in the line of sight, as given in the *Monthly Notices* for November 1875, and those obtained by Dr. Huggins, and has with justice pointed out that there are many difficulties attending all such observations. On these

points I wish to offer a few remarks, as the difficulties, to which P. Secchi refers, engaged my attention from the first: they were, in fact, pointed out to me by Dr. Huggins before spectroscopic observations were undertaken at Greenwich; and since that time much pains have been taken to perfect the adjustments of the spectroscopes, and to submit the pencil of rays from the comparison-light to identically the same conditions as those from the star.

In such a complicated instrument as the spectroscope, the errors of the many surfaces concerned are so combined with errors of adjustment of prisms, collimator, and telescope, that it has been a work of much labour to remove them one by one, though the peculiar form of the Greenwich Spectroscope has much facilitated the task. One important error in its bearing on this question appeared to be the astigmatism of the pencil after passing through the prisms (a defect which I have remarked in all spectroscopes that I have examined). This, after many attempts to improve the surfaces of the prisms by reworking, was corrected by means of a cylindrical lens within the collimator, and near the slit. I can hardly think that this error is caused by the surfaces of the prisms; but it may possibly have its origin in a variation of density in the glass, which is usually moulded. Another defect which gave much trouble was a slight wing to the lines (especially with a wide slit), which looked very like the error caused by tilt of a lens, but was ultimately traced to false light reflected from the base of the prisms. For this reason it is very important that the train be adjusted to minimum deviation, or rather to such a position that the pencil shall pass through the prism in a direction parallel to the base, and to the top and bottom. It is of no importance that the base should make equal angles with the two faces (though this is convenient for purposes of adjustment), for, with a pencil of parallel rays no astigmatism will be produced when the condition of minimum deviation is not satisfied. This condition, however, may serve as a convenient test of the parallelism of the pencil to the base of the prism; and, in fact, it was the want of such a test which made it difficult to adjust the "half-prism" with which the train begins. It was ultimately found, however, that, owing to greater density in the glass, the deviation through this "half-prism" was 5° greater than it should have been, and that, consequently, the pencil did not fall fairly on the successive prisms of the train, thus giving rise to false light on one side of the bright line viewed. This defect was corrected, and since last February the spectroscope appears to have been in perfect adjustment. But it appears to be of even more importance that the light which illumines the slit should form a pencil which just fills the whole of the object-glass of the collimator; for if the light fall obliquely on the slit, a false image may be formed by reflection from one of the jaws, or, perhaps in some cases, from within the collimator. I have seen a second or spurious pair of sodium lines formed in

this manner by the side of the regular image ; and Mr. Hilger informs me that he has frequently obtained a perfect image of the sodium lines from one jaw of a slit, when the other has been removed. It is difficult to trace the origin of such false light ; but I have found that it disappears when the incident-pencil is properly adjusted, and can therefore only suggest some such cause as I have indicated above. It was for this reason that the method of comparison by means of a vacuum tube placed within the great telescope in the course of the rays from the star was given up, although, in Dr. Huggins's hands, it certainly worked well. It would seem probable that the systematic error remarked in the measures between August 1874 and March 1875, was caused by reflection of some of the light from the sides of a small rectangular tube placed in the axis of the collimator close to the slit (to cut off false light), and that thus a false image was formed ; in any case, the two pencils from the star and comparison-light, passing through different portions of the collimator-object-glass and of the prisms, might be affected differently by optical defects. The method now adopted of throwing an *image* of the comparison-light on the slit by means of a collimating lens and small reflecting prism, appears to be free from the errors to which the use of a reflecting prism alone is liable; certainly no erroneous shift of the comparison-line has been detected since it was brought into use. The adjustment of the slit to the principal focus of the telescope is another important condition, which has been specially provided for in the Greenwich Spectroscope by means of a diagonal prism, which can be pushed into the course of the rays close behind the slit, allowing the latter to be viewed at the same time as the star by a suitable eyepiece. This arrangement serves as a finder, and also as a means to verify the position of the comparison-light and star on the slit, which can thus be reduced in width until it limits the star's image on both sides ; this will be seen to be a necessary condition for accurate comparison, when it is considered that one-thousandth of an inch at the slit corresponds, with the Greenwich Spectroscope (as ordinarily used for star motions), to about 15 miles a second in the motion of a star, whilst with such an instrument as P. Secchi's it would represent a much larger quantity. If P. Secchi had not used a sufficiently narrow slit, the appearances he describes of the star-line shifting its position when the driving clock of the equatoreal was stopped (allowing the star to travel across the slit) would be exactly accounted for.

I have entered into some detail on these matters, as the brief statement given in the *Monthly Notices* for last November seems to have been imperfectly understood, whilst P. Secchi apparently does not admit the propriety of rejecting the measures prior to 1875, May 31. These observations were given in order to show fairly the errors to which the method is liable, and the results could in any case only be considered as preliminary. In such an inquiry much experience is required, and large errors are there-

fore to be expected in the earlier measures. The observations, however, since the new method of comparison was adopted show few discordances of *sign*, and the measures of the *magnitude* of the displacement agree as well as can be expected, considering how small the quantity to be measured really is, and that before the bright line micrometer was introduced (1875, November 29) it was very difficult to see the pointer and star line at the same time.

Notwithstanding these difficulties, it is gratifying to find that, out of the list of 21 stars which have been observed, both by Dr. Huggins and Mr. Maunder, there are only two cases of discordance, as will be seen from the following table; and for both of these stars Dr. Huggins has expressed himself as dissatisfied with his observations: whilst the Greenwich results for these stars rest on too few observations at present.

Motions in the Line of Sight.

\+ denotes Recession; — Approach.

Star.	Huggins.	Greenwich.
α Andromedæ	—	— 35
Aldebaran	+ ?	+
Capella	+	+ 20
Rigel	+	+
Betelgeuze	+ 22	+ 75
Sirius	+ 18 to 22	+ 25
Castor	+ 23 to 28	+ 25
Procyon	+	+ 40
Pollux	— 49	—
Regulus	+ 12 to 17	+ 30
β Ursæ Majoris	+ 17 to 21	+
α Ursæ Majoris	— 46 to 60	—
β Leonis	+ ?	—
Spica	+	+
η Ursæ Majoris	+ ?	—
Arcturus	— 55	— 35
ε Boötis	—	—
α Coronæ	+	+
Vega	— 44 to 54	— 37
α Cygni	— 39	— 50
α Pegasi	—	— 27

In the above Table, in cases where the sign only is given, the observations are at present insufficient to determine the amount of the motion with any degree of certainty.

With regard to the amounts of the displacement, P. Secchi appears to be under a misapprehension, as it is in terms of the width of the narrow bright line of the vacuum tube, not of the broad line in the star, that the displacement is estimated. The great breadth of the latter in some stars (especially *Altair* and *Sirius*) constitutes one great difficulty of the observation, and the discordances in the case of *Altair* are, doubtless to be attributed to this cause, since a small error in the estimation of the centre of a broad band may easily be committed. Such a source of error will be sufficiently indicated by the discordances of the individual observations, independently of the notes of the observer; but there remains the question of the fixity of the centre of the F line as the pressure of the gas is increased. Dr. Huggins has fully discussed this point; and I need only refer to it to add that, by his kindness, I have had the opportunity of seeing his experimental verification of this fact. Independently of this, the fact remains that there is a relative displacement of the F line in the case of stars for which the breadth of the line is sensibly the same; besides which similar displacements are shown by the *b* lines (which are comparatively narrow), and accordant results have been obtained for the motion of *Arcturus* from the D, *b*, and F lines. An examination of the results for different stars on the separate nights of observation will show that the motions of approach and recession are fairly distributed; whilst the comparisons of the F line in the spectrum of the Moon (for which the motion is insensible) show conclusively that there is no systematic error arising from maladjustment of the spectroscope. In all the measures the greatest care has been taken to avoid bias, the observer being careful to make the bisection of the line in the spectrum of the star or Moon before that of the comparison spectrum was seen, and having generally no previous knowledge of the direction in which a displacement was to be expected. No observation has, under any circumstances, been suppressed, and consequently some of the measures might fairly be rejected on the ground of erroneous bisection.

Royal Observatory, Greenwich,
1876, *May* 12.

Spectroscopic Results for the Motions of Stars in the Line of Sight, obtained at the Royal Observatory, Greenwich.

(*Communicated by the Astronomer Royal.*)

The results here given are in continuation of those printed in the *Monthly Notices* for 1875, November, but for convenience of reference, those of the former measures which are considered trustworthy are repeated, together with the more recent results, and the means of the whole taken in the case of those stars which have been satisfactorily observed. Where no mean is set down the result is to be considered as still uncertain. Observations have been enclosed in brackets and rejected in forming the means, in cases where no estimation of the displacement was made, or where the measured and estimated motions differed by more than 50 miles a second. In the one case the circumstances were evidently very unfavourable, in the other there is a strong presumption of error. The estimated motions are given as a check on the micrometer measures, being made independently. The motions actually observed may be inferred from the concluded motions by algebraic addition of the corresponding Earth's motion.

The weights given are on a scale of 1 to 5 for each measure; in some few instances a weight of $\frac{1}{2}$ has been given when the observation appeared very uncertain. The width of the slit has been given, as this has an important bearing on the question of displacement; in some of the observations too wide a slit has been inadvertently used, but recently care has been taken to limit the width to $3^{\text{div.}}$, or about 0·004 inch as a maximum. The apparent diameter of the image of a third magnitude star is about $4^{\text{div.}}$, or 0·005 inch.

The only instrumental changes made since last November are: The adaptation to the small telescope of a bright-line micrometer on a new principle, by Mr. Hilger, which has been used regularly from 1875, November 29; an alteration in the angle of the "half-prism" with which the train commences, so as to decrease the deviation of the pencil passing through it, by about 5°, in order that it might pass through the other prisms of the train at the angle of minimum deviation, and the insertion of a Barlow lens in the small telescope, increasing the power to 23. These changes were completed 1876, February 18.

All the comparisons have been made by means of two comparison-prisms in connection with a collimating lens, throwing an image of the comparison-light on the slit, immediately above and below that of the star. The interval between these comparison-prisms can be decreased at pleasure, till they are brought into contact.

The results which follow are arranged in order of Right Ascension of the stars observed. The measures of the Moon have been made as a check on the system of observation.

Royal Observatory, Greenwich,
1876, *May* 12.

Motions of Stars in the Line of Sight in Miles per Second.

(+ denotes Recession; − Approach.)

1 div. in the width of the slit corresponds to 0·0013 inch.

Date.	Observer.	No. of Measures.	No. of Prisms.	Width of Slit.	Line.	Earth's Motion in Miles per Sec.	Concluded Motion of Star. Measured.	Concluded Motion of Star. Estimated.	Remarks.
						α Andromedæ.			
1875 July 29	M	2	1½	d 2·6	F	−14·8	−14·7	−11·2	Star line faint; sky hazy; weight 2.
Aug. 4	M	2	1½	2·9	F	−14·1	− 6·5	−17·2	Indirect comparison; weight 2.
30	M	2	1½	2·6	F	− 9·5	−28·3	−36·0	Indirect comparison; star line rather faint from cloud; weight 2.
Dec. 17	M	2	2½	3·1 & 4·2	F	+16·3	−39·2	−44·9	Indirect comparison; star line rather faint, but better seen than on any previous occasion; weight 4.
22	M	2	2½	2·9	F	+16·7	−71·3	−79·6	Direct comparison; wind very high and images very unsteady; weight 2.
						Mean	−33·	−39·	
						Aldebaran.			
1875 Nov. 29	M	2	1½	2·7	b_1	− 0·3	(+135·0)	(+80·8)	Comparison doubtful, the lines being very faint, and there being several close together.
Dec. 17	M	1	2½	6·7	b_1	+ 5·7	+35·1	+48·7	Line confused with others near; weight ½.

Date.	Observer.	No. of Measures.	No. of Prisms.	Width of Slit.	Line.	Earth's Motion in Miles per Sec.	Concluded Motion of Star. Measured.	Concluded Motion of Star. Estimated.	Remarks.
									Capella.
1875 Nov. 29	M	2	$1\frac{1}{2}$	d 3·0 & 2·1	F	− 3·8	+48·3	+55·2	Weight 2; line very difficult to see.
Dec. 22	M	3	$2\frac{1}{2}$	2·5	F	+ 3·2	+11·0	+19·1	Direct comparison; weight 13; star line seen better than ever before.
						Mean	+16·	+24·	
									Rigel.
1875 Dec. 22	M	2	$2\frac{1}{2}$	3·4, 3·7	F	+ 4·4	+25·2	+26·7	Wind high; line faint; weight 5.
									α Orionis.
1876 Mar. 15	M	2	$1\frac{1}{2}$	2·1	b_4	+17·8	+67·1	+92·0	Star line very dark; weight 4. } Telescope not very firm.
15	M	1	$1\frac{1}{2}$	2·4	b_1	+17·8	+93·8	+48·1	Weight 4. }
						Mean	+76·	+77·	
									β Aurigæ.
1875 Nov. 29	M	2	$1\frac{1}{2}$	1·3	F	− 6·4	(−128·2)	(−60·5)	Star line broad and ill-defined at edges; weight 8.
									Sirius.
1875 Dec. 22	M	2	$2\frac{1}{2}$	3·3 & 3·8	F	− 2·9	+31·1	+29·6	Direct comparison showed a small but distinct displacement to red; weight 10.
1876 Feb. 24	M	2	$2\frac{1}{2}$	2·1 & 1·7	F	+11·6	+13·9	+32·5	Very hazy; weight 4.
Mar. 17	M	2	$2\frac{1}{2}$	4·2 & 3·0	F	+13·8	+16·4	+22·1	Line very marked; star steady and clear; weight 10.
						Mean	+22·	+27·	

						Castor.			
1875	Dec. 17	M	2	$2\frac{1}{2}$	5·5	F	− 7·3	+61·3	+41·1	Weight 4.
1876	Feb. 23	M	2	$2\frac{1}{2}$	2·1 & 2·2	F	+13·3	+24·2	+13·7	Very tremulous; weight 5.
	Mar. 17	M	2	$2\frac{1}{2}$	3·1 & 1·0	F	+17·0	+15·5	+22·5	Weight 8; direct comparison showed a slight displacement to red.
							Mean +29·		+24·	
						Procyon.			
1875	Dec. 17	M	2	$2\frac{1}{2}$	5·0	F	− 8·6	+34·3	+35·1	Weight 4; lines appeared nearly coincident; images steady, but spectrum not bright.
1876	Mar. 17	M	2	$2\frac{1}{2}$	1·0 & 1·4	F	+15·9	+59·4	+54·5	Weight 9; direct comparison showed a displacement to red greater than *Castor* or *Sirius*.
	Apr. 3	M	2	$2\frac{1}{2}$	1·1	F	+17·3	+33·7	+19·7	Weight 6; line faint and ill-defined; direct comparison showed a considerable displacement to red.
							Mean +46·		+39·	
						Pollux.			
1876	Mar. 15	M	2	$1\frac{1}{2}$	1·5, 1·9	b_4	+16·4	−127·9	−86·5	Star line very faint; measure rather wide; weight 3; telescope not very firm.
						Regulus.			
1876	Feb. 23	M	2	$2\frac{1}{2}$	0·6 & 1·4	F	+ 2·2	+11·6	+21·4	Weight 6.
	Mar. 17	M	2	$2\frac{1}{2}$	4·1 & 3·1	F	+ 9·1	+47·8	+43·9	Weight 7.
	Apr. 8	M	2	$2\frac{1}{2}$	1·9 & 2·9	F	+14·2	+32·1	+34·1	Weight 8; star line dark, but wind high.
	May 6	M	1	$2\frac{1}{2}$	1·4	F	+17·6	+32·8	+15·9	Weight 1; star line very faint, and measure doubtful.
							Mean +32·		+33·	

Date.	Observer.	No. of Measures.	No. of Prisms.	Width of Slit.	Line.	Earth's Motion in Miles per Sec.	Concluded Motion of Star. Measured.	Concluded Motion of Star. Estimated.	Remarks.
							γ Leonis.		
1876 Mar. 15	M	3	$1\frac{1}{2}$	d 3·2, 2·5	b_1	+ 8·5	−71·3	−65·7	Star line not very pronounced; weight 6; telescope not very firm.
							β Ursæ Majoris.		
1876 May 1	M	3	$2\frac{1}{2}$	3·0, 1·5	F	+12·6	+15·5	+15·4	Line evidently displaced to red, but neither spectrum nor line well seen; weight 7.
							α Ursæ Majoris.		
1876 May 1	M	2	$2\frac{1}{2}$	1·5	F	+11·6	−37·1	−40·3	Direct comparison showed a slight displacement to blue; weight 4.
							β Leonis.		
1876 Apr. 8	M	2	$2\frac{1}{2}$	1·9	F	+ 8·8	−32·7	−31·0	Star line exceedingly difficult to see; weight 2.
							Spica.		
1876 Feb. 23	M	2	$2\frac{1}{2}$	1·8	F	−13·0	+37·2	+50·1	Definition poor; weight 4.
							η Ursæ Majoris.		
1875 June 11	M	2	2	...	F	+10·3	(+37·4)	...	Star line very faint, and not often seen; readings uncertain.
25	M	2	2	22·4 & 9·5	F	+10·4	(−65·1)	(−102·2)	Star line scarcely visible; result uncertain, on account of the width of the slit.
July 12	M	1	2	2·3	F	+ 9·4	−43·5	−23·5	Star line very faint, and bisection uncertain; displacement small; weight 1.
1876 May 1	M	2	$2\frac{1}{2}$	2·2	F	+ 7·6	−26·5	−38·2	Weight 6 line fairly well seen.
						Mean	−29·	−36·	

Arcturus.

1876 Mar. 15	M	2	1½	2·2, 1·6	b_1	+ 7·1	−47·9	−43·7	Weight 10.
15	M	2	1½	3·0	D_2	− 7·1	−47·6	−33·5	Weight 2; D lines not seen nearly so well as the *b* lines.
Apr. 8	M	4	2½	0·9, 1·5	F	− 0·8	−16·0	−16·1	Weight 8; measures somewhat uncertain, as there was much mist, and the Moon was very bright.
May 6	M	2	2½	4·4	F	+ 6·4	−33·2	−47·0	Weight 4; very poorly seen.
						Mean	−35·	−34·	

ε Boötis.

1876 Mar. 15	M	2	1½	3·6	b_1	− 7·1	− 4·6	−13·3	Line faint; weight 4; image tremulous; telescope not very firm.

α Coronæ.

1875 June 25	M	1	2	1·5	F	+10·2	(−119·3)	(−30·5)	The two lines could not be directly compared; star line dark, and very broad and nebulous.
1876 Apr. 8	M	2	2½	2·2	F	− 4·7	+59·9	+45·5	Weight 1; measures very doubtful.

α Ophiuchi.

1875 June 25	M	2	2	2·7	F	+ 3·3	−26·6	−25·1	Indirect comparison; spectrum faint; star line slightly displaced to blue.
July 12	M	2	1½	2·1, 1·5	F	+ 7·1	(+154·3)	(+88·5)	Star line very faint, and not well seen.

Date.	Observer.	No. of Measures.	No. of Prisms.	Width of Slit.	Line.	Earth's Motion in Miles per Sec.	Concluded Motion of Star. Measured.	Concluded Motion of Star. Estimated.	Remarks.
									Vega.
1875 June 25	M	2	2	d 2·3	F	− 1·4	−47·7	−24·8	
26	WC	2	2	3·2, 1·8	F	− 1·3	−16·2	−19·4	Everything in good adjustment.
July 8	M	3	2	1·4	F	+ 0·4	−39·0	−13·6	
12	M	2	1½	0·5, 1·6	F	+ 0·9	−46·5	−65·5	Definition good.
29	M	2	1½	2·1, 2·3	F	+ 3·2	−37·7	−39·2	Direct comparison.
31	M	2	1½	2·8	F	+ 3·5	−54·1	−57·6	Very bright indeed; direct comparison.
31	M	2	2¼	5·1, 4·5	F	+ 3·5	−53·1	−35·8	
Aug. 30	M	3	2½	2·0, 2·4	F	+ 6·9	−49·0	−34·1	Sky hazy at times.
Sept. 3	M	2	3½	2·0	F	+ 7·2	−28·9	−23·9	Line broad and nebulous, and not very distinctly seen; indirect comparison.
1876 May 1	M	2	2½	3·1, 1·5	F	− 7·5	−17·4	−40·0	Weight 8; air steady, but sky hazy.
						Mean	−39·	−35·	
									Altair.
1875 June 26	WC	2	2	2·5, 3·1	F	− 6·7	(−102·1)	(−25·5)	Everything in good adjustment.
July 8	M	2	2	2·5	F	− 3·7	−58·2	−23·9	Star line not well seen.
12	M	2	1½	1·6	F	− 2·7	(+105·6)	(+85·4)	Direct comparison doubtful; star line faint, broad, and ill-defined.
29	M	2	1½	1·5, 2·7	F	+ 1·7	−81·3	−77·1	Indirect comparison; star line very faint.

Altair—continued.

31	M	1	2½	4·1	F	+ 2·2	+13·8	+21·2	The observations are discordant.
31	M	2	1½	4·1	F	+ 2·2	−22·2	...	
Aug. 4	M	2	1½	4·1, 2·4	F	+ 3·3	−86·8	−62·1	Direct comparison.
30	M	2	2½	2·5	F	+ 9·5	−61·4	−57·5	
Dec. 22	M	1	2½	...	F	+ 8·1	...	...	Star line seen considerably displaced to the blue, but no measures could be obtained.

α Cygni.

1875 July 29	M	2	1½	2·8, 2·2	F	− 4·1	(+58·1)	(+80·5)	Star line faint.
31	M	2	1½	3·6, 4·6	F	− 3·8	−69·7	−79·7	Indirect comparison; weight 6.
Aug. 2	M	2	1½	2·3, 1·9	F	− 3·6	−53·2	−47·6	Indirect comparison; weight 6.
30	M	1	2½	2·1	F	+ 0·5	(−20·7)	...	Nearly coincident.
30	M	1	1½	2·1	F	+ 0·5	−31·7	−35·5	Indirect comparison; weight 3.
Nov. 29	M	1	1½	4·4, 4·5	F	+ 9·7	−36·4	−33·4	Indirect comparison; star line faint; nearly coincident; weight 6.
						Mean	−50·0	−51·0	

α Pegasi.

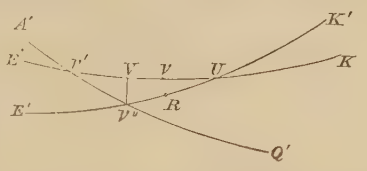
1875 July 29	M	2	1½	3·1, 3·6	F	−12·0	−10·3	−13·7	Indirect comparison; star line broad and dark; slightly displaced to blue; weight 4.
Aug. 4	M	2	1½	2·5	F	−10·7	−20·5	−14·8	Indirect comparison; weight 4.
30	M	2	1½	2·7, 3·1	F	− 4·3	−66·3	−39·5	Indirect comparison; weight 4.
						Mean	−32·	−22·	

Date.	Observer.	No. of Measures.	No. of Prisms.	Width of Slit.	Line.	Earth's Motion in Miles per Sec.	Concluded Motion of Star. Measured.	Concluded Motion of Star. Estimated.	Remarks.
				d				*Moon.*	
1876 April 3	M	1	2½	...	F	...	− 2·6	...	
„	M	1	2½	...	F	...	− 0·3	...	
„	M	1	2½	...	F	...	+ 7·9	...	Moon line very faint, much fainter than the line in *Procyon*, but not harder to bisect as it was of course narrow and sharp.
„	M	1	2½	...	F	...	− 3·0	...	
„	M	1	2½	...	F	...	+ 1·3	...	The spectroscope seemed in good adjustment.
„	M	1	2½	...	F	...	− 0·8	...	
„	M	1	2½	...	F	...	+ 8·9	...	
8	M	1	2½	...	F	...	− 9·4	...	Moon line fairly well seen, but faint.
„	M	1	2½	...	F	...	+13·7	..	Sharp but faint.
May 1	M	1	2½	...	F	...	− 1·5	...	Line very faint, and more difficult to bisect than the line in the spectrum of a large star would be.
„	M	1	2½	...	F	...	+ 9·1	...	
„	M	1	2½	...	F	...	+10·1	...	
3	M	1	2½	...	F	...	+ 4·0	...	Moon line seen better than on any previous occasion.
„	M	1	2½	...	F	...	− 4·1	...	Not quite so good, but very nicely seen.
6	M	1	2½	...	F	...	− 5·3	...	Moon line very well seen, easier to measure than *Vega* even.
„	M	1	2½	...	F	...	+ 4·8	...	
						Mean	+ 2·0		

The initials W. C. and M. are those of Mr. Christie and Mr. Maunder respectively,

On the General Precession. By Dr. Friedrich Wilhelm Berg.

Let EK be the ecliptic at the time T, E′K′ the ecliptic at the time T+t, and A′Q′ the equator at the time T+t; also let ν be the equinox at the time T, ν'' the equinox at the time T+t, ν' the equinox at time T+t, on the fixed ecliptic at the time T, and R that point in the ecliptic at the time T+t, which was at the time T in the ecliptic EK in ν. The arc $\nu\nu'$ is now called the Lunisolar Precession, and Rν'' the General Precession, both referring to the time T+t.



Now let us put

$$\nu\nu' = \psi, \quad R\nu'' = \psi_1, \quad \angle U\nu'\nu'' = \epsilon, \quad \angle U\nu''Q' = \epsilon_1, \quad \nu'\nu'' = \lambda;$$

and since

$$U\nu = UR,$$

we obtain from the triangle U$\nu'\nu''$

$$\tan\frac{\lambda}{2}\cos\frac{\epsilon_1+\epsilon}{2} = \cos\frac{\epsilon_1-\epsilon}{2}\tan\frac{\psi-\psi_1}{2};$$

and, consequently, neglecting the third and the higher powers of the time, we have

$$(1) \qquad \psi-\psi_1 = \lambda\cos\epsilon - \lambda\sin\epsilon\tan\frac{\epsilon_1-\epsilon}{2}.$$

Instead of the formula (1), Leverrier, in the *Annales de l'Observatoire de Paris*, vol. ii. p. 172, gives the formula—

$$\psi-\psi_1 = \lambda\cos\epsilon,$$

drawing the arc Vν'' perpendicular to the ecliptic EK, and putting

$$V\nu' = \psi-\psi_1.$$

But the approximation cannot be admissible, and putting

$$\angle K'UK = \eta, \quad \nu U = \Pi,$$

we obtain, neglecting the third power of the time—

$$\lambda = \frac{\eta\sin(\psi+\Pi)}{\sin\epsilon} - \frac{\eta^2\sin(\psi+\Pi)\cos\Pi}{\sin\epsilon}\cot\epsilon,$$

$$\frac{\epsilon_1-\epsilon}{2} = \frac{1}{2}\left\{\eta\cos\Pi - \eta\psi\sin\Pi + \frac{1}{2}\eta^2\cot\epsilon\sin^2\Pi\right\},$$

and therefore we obtain, from (1),

$$\psi - \psi_1 = (g + \Gamma) \cot \epsilon . t$$

(2)

$$+ \left\{ \left(\nu + a\,(g' + \Gamma') \right) \cot \epsilon - \frac{1}{2} (g + \Gamma)\ (g' + \Gamma') - (g + \Gamma)\ (g' + \Gamma')\ \cot^2 \epsilon \right\} t^2,$$

where (Leverrier, *loc. cit.*)

$$\eta \sin \Pi = (g + \Gamma)\, t + r t^2,$$
$$\eta \cos \Pi = (g' + \Gamma')\, t + r' t^2,$$
$$\psi = a\, t + b\, t^2;$$

and by substituting the numerical values, according to Leverrier (*loc. cit.*), we obtain from (2)

$$\psi - \psi_1 = \ 0''{\cdot}1356809\ t - 0''{\cdot}000221628\ t^2,$$
$$\psi_1 = 50''{\cdot}23572\ t \ + 0''{\cdot}00011282\ t^2.$$

Instead of these values, Leverrier gives (*loc. cit.*)

$$\psi - \psi_1 = \ 0''{\cdot}13568\ t - 0''{\cdot}00022170\ t^2,$$
$$\psi_1 = 50''{\cdot}23572\ t + 0''{\cdot}00011289\ t^2;$$

while the formula of Leverrier does not contain the term

$$-\frac{1}{2} (g + \Gamma)\ (g' + \Gamma') . t^2.$$

Wilna Observatory,
1876, *Jan.*

Note on the Satellites of Uranus. By E. Neison, Esq.

With the view of ascertaining whether the two outer satellites of *Uranus* were within the reach of a Newtonian reflector of $9\frac{1}{3}$-inch aperture, on the night of April 14, $8^h\ 0^m$ to $9^h\ 15^m$, the telescope was turned on the planet. The air was very steady, and definition very good. After putting *Uranus* into the field of view, this was constricted to a diameter of about $2'$, and the neighbourhood of the planet carefully examined for faint stars. After a prolonged and very careful search two were picked up, the planet all the time being kept beyond the field of view. Whilst looking at the fainter of the two, which was only seen with difficulty, the planet accidentally sailed into the field, without however in any manner interfering with the distinctness of this very faint object. It was found to be sensibly as easy to pick up the two stars with the planet in the field as with the planet out.

The distance and position-angle of the two stars were estimated as well as possible, with the following result:—

A	Very faint and difficult	Distance 15″–20″	Pos.-Angle 270°–280°
B	Fairly distinct	Distance 30–40	Pos.-Angle 100–110

On referring the next morning to the Ephemeris of Marth, it was found no satellite was in the position of the star B, but that A agreed well with the position of the III Satellite *Titania*, whose place was—

III Satellite, *Titania*	Distance 18″	Pos.-Angle 285°

The next night, April 15, being also very clear and steady, *Uranus* was again examined with a field of 2′ in an eyepiece magnifying 270, and, after a very careful search, three faint stars picked up.

C	Very faint	Distance 15″–20″	Pos.-Angle 230°–240°
D	Slightly brighter than C	Distance 30–40	Pos.-Angle 160–170
B	Bright and distinct	Distance 50–60	Pos.-Angle 100–110

On the next morning it appeared that the two faint stars C and D agreed to some degree of approximation with the positions of the III and IV Satellites, whose places were—

III Satellite, *Titania*	Distance 24″	Pos.-Angle 223°
IV Satellite, *Oberon*	Distance 44	Pos.-Angle 180

The third star B was obviously the same star as that seen the previous night and marked B, the planet having moved about 20″ further from it.

During the next week no night appeared to possess sufficient excellence of definition to render it worth while to turn the telescope on *Uranus*.

The 23rd of April turned out a fine, steady night, and from 8.30 to 9.15 the planet was examined. Two stars were picked up.

E	Very faint; only just visible	Distance 20″–25″	Pos.-Angle 320°–330°
F	Only suspected	Distance 40–50	Pos.-Angle 70–80

Reference to Marth's Ephemeris next day showed that E agreed to a certain extent with the position of the IV Satellite *Oberon*, whose place was

IV Satellite, *Oberon*	Distance 33″	Pos.-Angle 338°

The suspected star F, if it really existed, must have been a fixed star.

The night of April 25 was the finest night of the year, and no less than six stars were seen or suspected.

G	Very faint indeed; only suspected	Distance 35″–40″	Pos.-Angle 290°–300°
H	Comparatively distinct	Distance 60–80	Pos.-Angle 100°–110°
I	Faint, but fairly well visible	Distance 25–30	Pos.-Angle 250°–260°
B	Distinct and bright	Distance 120–140	Pos.-Angle 90°–100°
J	Very faint, and generally only glimpsed	Distance 20–25 or perhaps 30	Pos.-Angle 140°–160°

L Large bright star, 3′ or 4′ off, that had been seen on the 23rd, and precedes *Uranus*.

On the next day it was found that, according to the Ephemeris, I was the IV Satellite, probably *Oberon*, and J might have been the III Satellite *Titania*, the places being

III Satellite, *Titania*	Distance 32″	Pos.-Angle 188°
IV Satellite, *Oberon*	Distance 25	Pos.-Angle 253

The star B agreed in position with the star B seen on the nights of April 14 and 15.

Since April 25 moonlight has prevented further observations of the satellites or pseudo-satellites of *Uranus*.

On mapping down out of mere curiosity the places of the different stars seen around *Uranus*, on one plan, allowing for the motion of the planet, an entirely unforeseen result presented itself, when the stars seen on April 25 were inserted. For it was found that the star H seen on this night must have been on April 15 close to *Uranus*, its place being between Distances of 20″–30″, and Position-Angles 180°–220°. Considering the difficulty of estimating the distances and position-angles of these faint stars, it is perfectly possible that what was taken for the IV Satellite of *Uranus* on April 15 may have been this star, which was close to the place of the Satellite. It also appeared that the star G, which was suspected on the night of the 15th must, if it really existed, have been not far distant from the star seen on the 23rd in the position of the IV Satellite *Oberon*. Its place must have been between Distances 22″–27″, and Position-Angles 285°–300°. It is not however so likely as in the former instance, that this suspected star is what was seen, and taken for the Satellite of *Uranus*, since the position-angles differ considerably.

The point possesses, however, considerable interest, for it shows that a faint star being very approximately in the theoretical position of the satellite, is no proof that it actually is the satellite. The present observations show, however, that very probably the III Satellite *Titania* was seen on two occasions, and perhaps on a third; whilst the IV Satellite *Oberon* appears to have been seen for certain on one night, probably on another, and perhaps on a third.

On the Visibility of Oberon and Titania.

By George R. Rogerson, Esq.

Referring to Mr. Webb's communication to the Society at the meeting held on the 12th ult., on the subject of Mr. Ward's observations of the two exterior satellites of *Uranus*, Mr. R. C. Johnson (recently elected a Fellow of the Society) on the 25th of January, 1871, at 8.30 P.M., with a 9-inch silvered glass Newtonian by Browning, distinctly saw the two exterior satellites. The powers used varied from 200 to 650. Both were easily seen at once without previous knowledge of their positions, and *Titania* seemed only very slightly fainter than *Oberon*. Mr. Johnson frequently observed them afterwards, but considered them so easy to find that he only once entered them in his Note-book. Mr. Johnson tried to find the inner satellites, but, of course, without success.

Mr. Johnson thinks that with an 8 or $8\frac{1}{2}$-inch aperture they would be perceptible.

Waterloo Cottage, Liverpool,
1876, *May* 11.

A Catalogue of Red Double Stars.

By S. W. Burnham, Esq.

The following is a list of Double Stars situated within 121° of the North Pole, where one of the components has been set down as red in a greater or less degree, and is intended to include only such stars as are not found in the revised and enlarged edition of Schjellerup's *Catalogue of Red Stars*. These objects depend largely for their insertion here upon the authority of Sir John Herschel, and his partiality for red tints, long ago remarked, should be borne in mind, as in some cases later examination by other observers has shown the colours to be much less decided, or almost entirely wanting; but I have thought it better for the present to make the list nearly complete, leaving the work of making from all sources of information a carefully selected Catalogue of stars really red to some one more specially interested in this subject. Incidentally I have found many of these pairs from time to time, and in some instances have failed to notice any very positive red colour, but as these observations had for the most part a different object in view, I do not regard them of sufficient value to be recorded here.

The measures and magnitudes are generally from the Double Star Catalogues from which the pairs are taken.

Chicago, 1876, *April* 15.

No.	Designation.		R.A. 1880. h m s	Decl. 1880. ° ′	Pos.-Ang. °	Distance. ″	Mags.	Notes.
1	Σ 8	*Ceti* 27	0 5 25	− 3 45	292·6	7·31	7·2...8·8	*Subflava*; *cinerea*: Struve. Both red: South and Herschel,
2	Σ 11	...	0 8 20	+77 21	192·1	7·95	8·2...10·7	8·2 *subflava*: Struve. Large star *very red*: Hers.
3	Σ 46	55 *Piscium*	0 33 36	+20 47	192·7	6·37	5·0...8·2	*Egregie flava*; *eg. cærulea*: Struve. *Yellow*; *deep red*: Dembowski.
4	H. 626	W² O. 986	0 39 7	+31 1	330°	20·±	9...14	Large star *very red*: Herschel.
5	H. 628	W² O. 1137	0 45 25	+33 14	65·±	35·±	7...16	Large star *very red*: Herschel.
6	H. 1066	O² Arg. 1080	0 59 1	+62 2	302·2	6·±	9...14	Large star *ruddy*; small more so: Herschel.
7	H. 2079	Arg. (52°) 434	1 38 33	+52 50	300·±	8·±	9–10...15	Large star *very red*: Herschel.
8	H. 3461	ϵ *Sculptoris*	1 40 1	−25 39	72·5	3·±	6 ..10	Large star *white*; small *dull red*: Herschel.
9	Σ 163	O² Arg. 2027	1 42 35	+6416	33·6	34·93	6·2 ..8·2	*Rubroaurea*; *cærulea*: Struve.
10	H. 644	W¹ I. 736	1 42 22	+ 7 5	277·	15·±	8...14	Large star *very red*: Herschel.
11	Σ 188 *rej.*	...	1 50 47	+62 20	236·6	40·±	9...10	Very red; fine green: Herschel. (4th Cat.)
12	H. 647	W¹ I. 980	1 56 18	+ 7 6	50·±	30·±	10...10–11	Large star *deep blood red*, a very intense and remarkable colour; small star *green*: Herschel. The principal star is 9 mag. in Weisse. Position-angle appeared too large, and colour not very striking with 6-in.: Burnham.
13	H. 2129	Arg. (76°) 79	2 15 50	+76 40	159·4	10·±	10...14	Large star *very red*: Herschel. In Arg. mag. 9·5.
14	H. 652	...	2 26 7	+ 9 3	320·±	2½·±	10...10+	Elegant; *both ruddy*: Herschel.
15	H. 653	W² II. 598	2 26 26	+30 53	43·±	17·±	9...12	*Orange red*; *blue*: Herschel.
16	H. 2146	...	2 29 30	+76 18	82·5	30·±	10=10	Both stars *red*: Herschel.

17	H. 2166	...	2 53 55	+75 19	251·3	40· ±	8·9...10	Large star *very ruddy*: Herschel.
18	H. 2168	...	2 56 30	+70 58	294·1	12· ±	10...11	Large star *very red*: Herschel.
19	H. 2173	L. 5686	3 2 13	+73 25	164·3	25· ±	6–7...12	Large star *very ruddy*: Herschel.
20	Σ 416 *rej.*	...	3 28 2	+19 24	44·7	25· ±	9...10	*Red*; *blue*: Herschel (5th Cat.)
21	H. v. 13	ϕ *Tauri*	4 12 58	+27 4	241·8	55·9	6...8½	*Light red*; *cerulean blue*: Smith. *Red*; *bluish*: South and Herschel.
22	H. 344	Arg. (33°) 883	4 28 26	+33 41	95· ±	10· ±	10...14	Large star *very red*; small *dusky red*: Herschel. An observation in 7th Cat. gives magnitudes 8...9. Feb. 1876, *reddish*; magnitudes 8½...14: Burnham. The largest star is 8·4 mag. in Arg.
23	Σ 579	...	4 34 32	+22 30	30·1	16·48	8·5...10·7	8·5 *rubroflava*: Struve.
24	H. 2244	Rad. 1356	4 52 16	+69 12	166·	100· ±	9...9	Both stars *remarkably red*: Herschel. The other star is R. 1357.
25	Σ 649	W¹ IV. 1399	5 2 35	− 8 49	80·8	21·59	7·0...8·7	*Alba*; *cærulea*: Struve. *White*; *very ruddy*: Herschel (*Cape Obs.*)
26	Σ 648	W² IV. 1453	5 3 14	+31 53	74·3	4·68	7·4...8·1	*Subflava*; *subcærulea*: Struve. In two observations Dawes calls the large star *red*, or *reddish*.
27	H. 3752	P. V. 70	5 16 51	−24 54	110·1	2·86	6...8	White; red: Smyth.
28	H. 701	Arg. (31°) 992	5 22 48	+31 25	...	...	9...15	Large star *very red*: Herschel. The mag. in Arg. is 7·1.
29	Σ 724	W¹ V. 530	5 23 36	+10 55	241·5	6·86	8·7...10	Small star *very red*: Herschel. (7th Cat.)
30	Σ 783	...	5 37 0	+28 58	358·8	9·81	8·0...9·7	*Eg. alba*; *rulropurpurea*: Struve. *White*: Secchi.

No.	Designation.		R.A. 1880. h m s	Decl. 1880. ° ′	Pos.-Ang. °	Distance. ″	Mags.	Notes.
31	Σ 790	*Orionis* 187	5 40 5	− 4 19	89·1	6·82	7·0...9·3	*Rubroflava; cærulea*; colores insignes: Struve.
32	Σ 823= H. 375	W² V. 1294	5 51 56	− 7 40	339·3	7·50	8·5...9·2	*Albæ*: Struve. *Both red*: Herschel.
33	H. 3823	...	5 55 53	−31 4	131·5	3·±	9=9	Both stars *orange* or *even red*; very decided colours: Herschel.
34	Σ 840	...	5 59 48	+ 10 46	247·2	21·14	6·2...8·5	A and B C } B C *rubea*; D¹ = 0″·55 (1857·1):
					183·4	0·91	8·7	B and C } Secchi.
35	Σ 875	W¹ VI. 142	6 6 37	−13 7	334·9	6·05	8·7...9·8	*Red*; *very green*: Herschel (*Cape Obs.*)
36	H. 383	...	8 34	− 2 39	285·±	2·±	10...10	Both very ruddy: Herschel.
37	H. 3845	...	12 1	−22 40	51·3	25·±	8...12	Large star *ruddy*: Herschel.
38	Σ 895 *rej.*	W² VI. 372	6 14 23	+ 5 48	59·8	40·±	8–9...11	In two observations Herschel notes the larger star as *red*, and *very red*, and the comp. *blue* and *green*. Later the colours are given as *orange*; *fine blue*.
39	H. 725	...	6 14 24	+ 9 47	75·±	20·±	8·9...10	*Ruddy*; *purplish blue*: Herschel.
40	H. 735	W² VI. 895	6 32 6	+35 32	80·±	3·±	9...11	*Ruddy*; very elegant: Herschel.
41	Σ 983= H. 403	...	6 48 14	+34 37	36·6	11·85	7·7...11·7	7·7 *flava*: Struve. *Red*; *bluish*: Herschel.
42	H. 412	Arg. (24°) 1531	6 59 48	+24 22	20·±	35·±	7...17	Large star *red*: Herschel.
43	H. 756	...	7 14 2	+34 55	60·±	10·±	9·10...15	Large star *red*: Herschel. This pair is indentical with H. 417, but no mention of colour in that observation.
44	S.B. 198	L. 14503	7 20 36	−20 43	212·	3·5	8...11	Large star *red*: Burnham.

45	H. 2391	O¹ Arg. 6862	7 23 9	−26 36	292·2	15·±	8-9...14	Large star *very red*: Herschel.
46	H. 3973	...	7 26 36	−20 41	36·3	8·±	9...10	Pure *white*; remarkable *brick red*: Herschel.
47	H. 772	...	7 54 0	+35 46	35·±	5·±	11...12	A *red* star $7^m\ 2^s$ distant in the direction of 120°: Herschel.
48	Σ 1202	P. VIII. 13	8 6 59	+11 13	325·3	2·03	7·7...9·8	Binary; 7·7 *alba*: Struve. *Reddish*: Dawes.
49	S.B. 207	L. 17091	8 33 44	−19 19	103·5	4·40	6·5...10·5	Decidedly *reddish*: *blue* (?): Burnham.
50	H. 110	*a² Cancri*	8 51 54	+12 19	320·±	10·±	4-5...20	*White*; *red*: Herschel. Dembowski has measured this with $7\frac{1}{2}$-in., and calls the small star 11·0 mag. of Struve's scale.
51	H. 121	...	9 7 9	+10 21	70·±	1·±	10...	Both *red*: Herschel.
52	Σ 1371	W² IX. 615	9 29 10	+ 4 27	279·8	7·11	8·0...10·5	Small star *dusky red*; a very remarkable colour: Herschel (5th Cat.)
53	H. 149	...	9 54 46	+ 5 36	265·±	30·±	...	*Red*; *purple*: Herschel.
54	H. 159	W¹ X. 209	10 14 3	+11 57	15·±	35·±	8...10	*Red*; *blue*: Herschel.
55	H. 183	W. XI. 529	11 31 48	+13 37	20·±	60·±	...	*Red*; *bluish*: Herschel. In Weisse, 8 mag.
56	H. 506	...	11 32 26	+38 51	135·±	15·±	7...15	Large star *red*: Herschel. There is certainly no such star in this place. Exactly 1° North is a yellowish 7 mag. star, but I could not see any companion with 6-in., though carefully looked for. There is nothing in H.'s place brighter than about 10 mag.
57	H. 1201	B.A.C. 4005	11 44 48	+12 54	189·0	12·±	6-7...13	Small star *red*: Herschel. The principal star 6 mag. in Arg.
58	H. v. 121	12 *Comæ*	12 16 28	+26 31	168·2	66·1	5...8	*Straw-yellow*; *rose-red*: Smyth.
59	Σ 1664	W¹ XII. 508	12 32 6	−10 51	254·7	19·44	7·7...8·8	*Flava*; *cærulea*: Struve. *Red*; *blue green*: Herschel (*Cape Obs.*)

No.	Designation.		R.A. 1880. h m s	Decl. 1880. ° ′	Pos.-Ang. °	Distance. ″	Mags.	Notes.
60	H. 1221	...	12 37 56	+74 11	260·±	...	...	Fine coarse double star. *Red*; *blue*: Herschel.
61	...	Lac. 5686	13 42 15	−27 46	110·2	77·	7...10	A beautiful deep red or crimson star, with a distant bluish companion. This was found after the completion of this list (April 17, 1876). Called 8 mag. by Arg. and 7·7 in Washington Catalogue, and may therefore be variable. Companion approximately measured.
62	H. 1249	O[1] Arg. 13508	14 10 25	−15 53	167·7	6·±	8–9...11	"The large star a fine red, between rose and garnet. It is rather a florid than a deep blood-red": Herschel. In the 5th Cat. it is described, "large star very high red, between orange and ruby."
63	H. 546	B.A.C. 4777	14 18 48	−12 49	40·±	30·±	5·6...11	*Red*; *blue*: Herschel. The correct place is given, Herschel's being erroneous in R.A. and Decl.
64	Sh. 184	54 *Hydræ*	14 39 4	−24 56	136·7	10·	5·5...7·5	Red; blue: South and Herschel.
65	Σ 1894	18 *Libræ*	14 52 24	−10 40	38·7	19·4	6·0...10·2	6·0 *subflava*: Struve. *Straw colour*; *grape red*: Smyth.
66	H. 2772	O. Arg. 15242	15 11 32	+45 18	309·	10·±	9–10...13	*Both ruddy*: Herschel.
67	H. 4767	...	15 17 58	−26 20	140·±	30·±	8½...11	*Red*; *blue*: Herschel.
68	Sh. 239	43 *Herculis*	16 40 4	+ 8 48	230·9	80·09	5...9	*Decidedly red*; *bluish*: South and Herschel. *Rose tint*; *light blue*: Smyth. *Golden*; *blue*: Demb.
69	H. 1294	L. 30509	16 40 56	−24 19	136·±	18·±	7...17	Large star *red*: Herschel.
70	Σ 2110 *rej.*	56 *Herculis*	16 50 6	+25 56	96·	15·±	6½...13	*Light yellow*; *pale red*: Smyth. *Reddish*; *bluish white*: South and Herschel.
71	Σ 2253	W[1] XVII. 1073	17 52 55	+14 38	80·4	18·1	7·5...10·2	7·5 *subflava*: Struve. Large star *red*: Herschel.

72	Σ 2264	95 *Herculis*	17 56 24	+21 36	261·7	6·06	4·9...4·9	*Flavasubviridis*; *flavasubrubra*: Struve. *Light apple-green*; *cherry-red*: Smyth. *Pale red* to *orange*: Dawes.
73	H. 2832	...	18 20 58	−21 19	15·0	18·±	9·10...11	Large star *very red, almost ruby*: Herschel.
74	Σ 2319	W² XVIII. 607	18 22 30	+19 13	191·0	5·61	7·2...7·6	*Albæ*: Struve. Both stars *pink*: Dawes.
75	H. 5499	...	18 32 10	− 4 25	155·±	15·±	9...12·5	Large star *very red*: Herschel.
76	H. 1322	...	18 33 47	+24 33	224·0	18·±	8...11	Small star *ruddy*: Herschel.
77	H. 1337	W² XVIII. 1064	18 36 22	+31 28	174·9	6·±	9...12	Small star *ruddy*: Herschel.
78	H. 2852	...	18 57 16	+ 7 14	134·5	18·±	10...12	*Red*; *blue-green*: Herschel.
79	H. 1365	...	19 0 21	+26 57	327·5	15·±	9–10...10	*Ruddy*; *green* by contrast: Herschel.
80	H. 881	Schj. 7257	19 11 43	− 5 38	340·±	30·±	7	A and B } Curious case of contrasted colours. Large
					310·±	3·±	11...11	B and C } star *red*; small stars *blue*: Herschel.
81	H. 1453	...	19 50 41	+24 20	227·1	23·±	9=9	The preceding star *reddish*: Herschel.
82	...	...	19 55 25	+ 0 20	*s.p.*	10·±	9–10...15	*Red*; *blue*: Harvard Zones.
83	H. 1470	L. 38428	19 59 18	+37 59	332·5	25·±	8–9...10	*Ruddy-yellow*; *contrasted green*: Herschel. *Rubra*; *cærulea*; colori superbi. Secchi. Mags. 7...8; called "Nova." The double star H. 605 having nearly the same R.A., but Decl. uncertain, given as between 38° and 40°, is undoubtedly identical with this. It is there described as *dark red*; purple; P = 340·° ±; D = 20·″ ±; mags. 9...12. Both stars are observed by Arg. magnitudes 7·2...9·4.
84	H. 1529	...	20 27 0	− 6 38	114·0	25·±	7·8...11	Large star *red*: Herschel.
85	H. 2988	...	20 35 52	+ 2 32	139·7	20·±	9...11	Large star *very red*: Herschel.

No.	Designation.		R.A. 1880. h m s	Decl. 1880. ° ′	Pos.-Ang. °	Distance. ″	Mags.	Notes.
86	H. 1582	...	20 45 12	+38 5	328·0	25·±	9–10...12	Large star red: Herschel.
87	H. 2985	B.A.C 6999	20 46 27	+88 57	289·4	60·±	5–6...13	A *ruddy* bright star: Herschel.
88	H. 3005	...	20 48 6	+ 3 30	292·2	18·±	8–9...12	Large star *very red*: Herschel.
89	H. 5265	...	21 15 11	−22 53	196·7	20·±	9...9½	*Red*; *blue*: Herschel.
90	Σ 2790	B.A.C. 7417	21 15 55	+58 7	46·5	4·54	5·6...9·9	*Eg. rubra*; *cærulea*: Struve. *Orange*, 1871: Webb.
91	H. 1650= O Σ 440	B.A.C. 7476	21 24 16	+59 14	189·6	12·2	6·2...11·0	6·2 *orange*; *red*: Herschel. *Jaune orange*: Dembowski.
92	H. 1669	O² Arg. 12555	21 32 1	+49 57	239·8	12·±	8...13	White; red: Herschel.
93	Σ 2850	...	21 54 16	+23 22	263·2	2·83	7·2...11·2	7·2 *rubroaurea*: Struve.
94	Σ 2895	W² XXII. 314	22 15 8	+24 21	6·1	4·80	8·5...10·0	8·5 *flava*: Struve. Red: Herschel. (5th Cat.)
95	Σ 2913	W¹ XXII. 477	22 24 14	− 8 44	331·9	8·01	7...8	*Alba*; *subrubra*: Struve.
96	H. 296	...	22 24 41	+12 32	220·±	12·±	9...11	Large star *ruddy*: Herschel.
97	O Σ 478= Σ 2942	B.A.C. 7931	22 38 39	+38 50	280·6	2·80	6·0...8·4	*Aurorosea*; *cinerea*: Struve. *Coul. d'or*; *cendré*: Dembowski. B *very red*: Wilson and Seabroke. Error of 2ᵐ R.A. in *Mens. Micr.*
98	H. 3152	L 44810	22 48 40	+10 1	135·4	3·±	9...15	Large star *very red*: Herschel.
99	H. 975	W² XXII. 1133	22 50 9	+35 43	235·±	50·±	6...9	*White*; *red*: Herschel. This is No. 239 of the Pulkowa Cat. of wide pairs.
100	H. 1839	...	22 54 52	+40 29	293·5	15.±	10...12	Small star *dusky red*: Herschel.
101	S.B. 181	*Aquarii* 286	23 7 31	−14 3	309·8	1·42	7.0...10·5	Large star *reddish*—decided contrast in the two: Burnham. Measures by Dembowski.
102	Σ 3038= H. 1907	...	23 40 23	+62 0	274·9	4·36	9...9·5	*Albæ*: Struve. Both *very red*, almost ruby colour: Herschel.

Note on Dr. Royston-Pigott's Starlit Transit Eye-piece.

By Capt. Wm. Noble.

Having been favoured, through the kindness of Dr. Royston-Pigott, with one of the Starlit Transit Eye-pieces, described by him before our March meeting, I have thought that a short Note on the result of the experiments which I have, so far, been able to make with it, may not be wholly destitute of interest.

Briefly then, I may say that I find that the mean transit of a star over the five lines ruled upon the silvered glass surface, differs some 0·3 or 0·4 second from that of its passage over (or through) the central line; and, inasmuch as the intervals between any two adjacent pairs of lines may be held to be mathematically equal, this affords a very fair indication of the degree of accuracy attainable with Dr. Royston-Pigott's most ingenious contrivance.

With my 4·2-inch Equatoreal of 61 inches focal length, the eye-piece I have gives a measured power of exactly 84.

A noticeable effect is produced by the passage of a "ghost" of every object observed, in a diametrically opposite direction, across the field.

Forest Lodge, Maresfield, Sussex,
1876, *May* 11.

Note on Coggia's Comet (III. 1874).

By J. Dreyer, Esq.

The accompanying sketches of the great Comet of 1874 were made by me while working at the Copenhagen Observatory with the refractor of 11-inches aperture. As the attention was principally directed to micrometrical observations, exact sketches of the head of the Comet were only made on three nights, June 20, July 13 and 16. I have thought they might be of some interest to the Fellows of the Society as a supplement to the drawings published in the March number of the *Monthly Notices.*

On the 20th June the nucleus was equal to a star of the fifth magnitude and the light in front of it was like the top of a fountain.

On the 13th July the Comet appeared as represented in the second sketch. The following branch was brighter than the preceding one. Two luminous tails streamed out from the foremost part of the coma, turning back left and right. They were decidedly brighter than the region round the nucleus. A faint parabolic arc of light was seen in front of these tails. The

nucleus was pretty sharply defined and formed the centre of a small sector of light, which faded away gradually. The sketch was taken at 11^h M.T.

On the 16th July the Comet was so near the horizon, that faint details could not be seen. The drawing was made at 10^h 20^m M.T. The two tails were seen again, but now streaming out directly from the nucleus. The preceding one could be traced out to the periphery of the parabolic coma, while the following one was shorter and faded away following.

June 20. July 13. July 16.

Coggia's Comet (III. 1874).
As seen with the 11-in. Refractor at Copenhagen.

The Earl of Rosse's Observatory,
1876, *May.*

Note on the Conjunction of Venus and λ *Geminorum on* 1876, *August* 17–18. By E. Dunkin, Esq.

Dr. Krüger, of Helsingfors, has drawn the attention of the Astronomer Royal to a very close approach of *Venus* to the star λ *Geminorum* on the morning of August 18 next, and he remarks that an opportunity will thus be afforded at the Northern and Southern observatories for making simultaneous micrometrical-measures of the distance between the planet and the star, the latter being, according to the *Uranometria Nova* of Argelander, of the 4–3 magnitude, and according to Heis, of the fourth magnitude. As a series of measures made in both hemispheres would be of some importance, it may be useful, for the convenience of observers, to insert in the *Monthly Notices* the tabular R.A. and N.P.D. of *Venus* for short intervals during the morning of August 18, and also the apparent place of λ *Geminorum* for the same day, deduced from the Greenwich *Seven-Year Catalogue* for 1864. Viewing this interesting conjunction as one of more than usual value, it is hoped that attempts will be made on this side the Atlantic to secure some micrometrical-measures, although the nearest approach occurs in Europe several hours after sunrise; but the star being of a fair magnitude, it is possible that at, or slightly before that time, it may be observable with some of our large telescopes. In North and South America, where the

nearest approach takes place before sunrise, measures may be made at the most favourable time without any difficulty.

The apparent R.A. and N.P.D. of λ *Geminorum* on August 18, are—

R.A.			N.P.D.		
h	m	s	°	′	″
7	10	59·30	73	14	8·17

The relative positions of *Venus* and the star may readily be found from the following interpolated hourly places of the planet, deduced from the daily places in the *Nautical Almanac*, and compared with the apparent R.A. and N.P.D. of the star given above:

Greenwich Mean Time, 1876.		R.A. of *Venus*, interpolated from *N.A.*			N.P.D. of *Venus*, interpolated from *N.A.*			R.A. of *Venus* − R.A. of Star.	N.P.D. of *Venus* − N.P.D. of Star.	
d	h	h	m	s	°	′	″	s	′	″
Aug. 17	16	7	10	31·97	73	16	3·7	−27·42	+1	55·5
	17		10	36·58		15	57·6	−22·81	+1	49·4
	18		10	41·20		15	51·6	−18·19	+1	43·4
	19		10	45·83		15	45·5	−13·56	+1	37·3
	20		10	50·48		15	39·5	− 8·91	+1	31·3
	21		10	55·14		15	33·5	− 4·25	+1	25·3
	22		10	59·81		15	27·5	+ 0·42	+1	19·3
17	23		11	4·49		15	21·5	+ 5·10	+1	13·3
18	0		11	9·18		15	15·5	+ 9·79	+1	7·3

The apparent semidiameter of *Venus* at the time of nearest approach on August 17, 22^h is $19''·1$.

It may be remarked that the nearest approach occurs half-an-hour before sunrise at Washington, *Venus* being about 27° above the horizon. At Santiago de Chile the planet will be about 12° above the horizon at this time, or nearly an hour-and-a-half before sunrise.

The favourable positions of observatories in America is, however, better shown by the numbers in the following table, which gives the local mean times of the conjunction of the planet and star in R.A. and of sunrise, together with the corresponding altitude of *Venus* for the Observatories of Ann Arbor, Washington, and Santiago de Chile:—

		Local M.T. of Conjunction.			Local M.T. of Sunrise.			Altitude of *Venus*.	
		d	h	m	d	h	m	°	′
Ann Arbor	Aug.	17	16	21	17	17	16	21	35
Washington	„	17	16	48	17	17	22	26	32
Santiago	„	17	17	13	17	18	38	12	5

Kidbrooke, Blackheath,
1876, *May* 6.

Note on the Discovery of Four Minor Planets, (160) *Una,* (161), (162), *and* (163). By E. Dunkin, Esq.

Since the tabular statement given on page 189 of the last Annual Report was prepared, four additional planets have already been discovered. The detection of so many new members of the group of planetoids of about the twelfth magnitude, leads us to believe that the group contains a large and probably indefinite number of planets even more minute than those which are known to exist, and consequently our interest in these frequent planetary discoveries has of late considerably diminished. But so long as observers continue to have the zeal to search for new planets, it is important that a current record of each discovery should be inserted in the *Monthly Notices*, for reference, as soon as possible after its announcement, although it is usual to give an annual summary of the year's planetary discoveries in the next Report of the Council. This duty naturally falls on the Secretaries, and I have therefore collected together from different sources the following early observations of the four new planets made at European observatories to the end of April.

Minor planet (160) *Una* was discovered by Dr. C. H. F. Peters at the Litchfield Observatory, Clinton, New York, on 1876, February 20. Magnitude the twelfth. From observations made at Clinton on February 24, and at Berlin on March 16 and 31, Dr. A. Schmidt has calculated the following elements:

Epoch: 1876, March 16·5, Mean Time Berlin.

		°	′	″	
M	=	93	31	20·7	
ω	=	47	31	29·3	Mean Eq. 1876·0.
Ω	=	9	18	3·3	
i	=	3	51	16·6	
ϕ	=	3	27	44·6	
μ	=	785″·136			
log a	=	0·436708			

Minor planet (161) was discovered by Mr. Watson at Ann Arbor, Michigan, on April 18. A telegram was received by the Astronomer Royal from the Smithsonian Institution on the evening of April 19, which was communicated to the daily newspapers without delay. "Planet; Watson; R.A. = $13^h\ 28^m$; Decln. = 11° 45′; daily motion 2′ north; magnitude eleven." The following early observations of the planet have been made in Europe.

1876.	Mean Time. h m s		Observed R.A. h m s	l.f.p.	Observed N.P.D. ° ′ ″	l.f.p.	Mag.
April 20	11 28 58	Berlin	13 27 10·44	7·107	101 43 10·2	0·901	10·5
20	15 17 22	Marseilles (*a*)	13 26 58·74	9·573	101 42 41·4	0·826	11·0
22	10 2 26	„ (*a*)	13 25 4·23	9·173	101 39 14·5	0·858	11·0
22	12 34 45	Paris	13 24 56·76	9·110	101 39 6·5	0·887	
23	12	Lund	13 23 51		101 36 54		
30	13 26 16	Berlin	13 16 45·83		101 23 58·9	0·886	

Minor planet (162) was discovered by M. Prosper Henry at the Observatory of Paris on April 21. It was of the twelfth magnitude. The following early observations have been communicated to the Society:

1876.	Mean Time. h m s		Observed R.A. h m s	l.f.p.	Observed N.P.D. ° ′ ″	l.f.p.	Mag.
April 21	13 15 50	Paris	14 9 57·83	9·069	102 18 37·7	0·889	12·0
22	11 6 30	Marseilles (*b*)	14 9 10·95	9·042	102 16 46·4	0·864	11·5
22	11 24 34	Paris	14 9 10·00	8·832	102 16 41·3	0·891	
24	10 31 36	„	14 7 29·39	9·153	102 12 0·9	0·888	
25	9 41 59	Marseilles (*c*)	14 6 39·84	9·372	102 8 59·6	0·853	11·5
28	11 53 31	Paris	14 4 0·59	8·514	102 3 12·8	0·891	
30	12 36 8	Berlin	14 2 18·86	9·049	101 59 16·2	0·900	12·0

Minor planet (163) was discovered by M. Perrotin at Toulouse on April 26. Magnitude the twelfth.

1876.	Mean Time. h m s		Observed R.A. h m s	l.f.p.	Observed N.P.D. ° ′ ″	l.f.p.	Mag.
April 26		Toulouse	14 11 48		96 24		12·0
27	8 43 10	Marseilles (*d*)	14 10 54·38	9·496	96 19 13·9	0·816	12·0
28	10 9 11	Paris	14 9 54·67	9·189	96 13 16·6	0·860	
29	13 49 9	Berlin	14 8 51·66	9·299	96 7 3	0·874	
30	14 33 48	„	14 7 54·90	9·417	96 1 26·3	0·868	

M. Stéphan has also forwarded to the Society the mean positions of the four comparison-stars observed at Marseilles, derived from Weisse's Bessel, first Catalogue. The observations were made by M. Borrelly:

		R.A. h m s	N.P.D. ° ′ ″
a	W.B. xiii. 402	13 25 50·61	102 1 21·9
b	W.B. xiv. 181	14 12 5·82	102 0 39·2
c	W.B. xiv. 49	14 5 9·27	102 0 2·9
d	W.B. xiv. 186	14 12 9·89	96 26 15·8

Kidbrooke, Blackheath,
*d*1876, *May* 6.

Supplementary List of Wide Double Stars taken for the most part from Smyth's Celestial Cycle, and not included in other Catalogues. By M. Camille Flammarion.

(*Communicated by the Rev. R. Main.*)

Cat. H.	S. C. C.		
1090	121	η Eridani	
1569	159	γ Tauri	
2072	200	γ Orionis	
2124	208	β Leporis	
2152	213	α Leporis	
Cat. H.	S. C. C.		
2584	243	μ Geminorum	(If the distance = 80^s in time, and not 80″)
2724	254	γ Geminorum	(If the distance = 76^s in time, and not 79″)
3009	278	δ Canis Majoris	
3162	287	η Canis Majoris	(Is there not a star at 90″?)
3786	327	δ Hydræ	
3806	333	ϵ Cancri	
4251	366	ψ Leonis	
5480	469	ϵ Virginis	
5631	485	79 Virginis	
6636	563	δ Ophiuchi	
6730	578	β Herculis	
6928	601	η Ophiuchi	
7631	668	σ Sagittarii	
8178	719	Piazzi xxix. 295	
10129	840	ι Piscium	

Near Approach of 47 Geminorum, April 1.

By the Rev. S. J. Johnson.

Predicted as an occultation for 26 min. at Greenwich. Here, lat. 50° 48′ 45″, long. 14^m 34^s W., the star escaped being occulted. At the nearest appulse 7^h 46^m it was distant 25″ by estimation from the Moon's bright limb. On passing close by the terminator, where there were several bright spots in the dark part of the Moon, it conveyed to the eye the impression of being an additional lunar peak caught by the Sun's rays. Another star, about $\frac{1}{2}$-mag. lower, probably Σ 1037, disappeared behind the dark limb at 7^h 42^m·5. Sky cloudless.